SUPERLUMINAL RELATIVITY RELATED TO NUCLEAR FORCES AND STRUCTURES

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Cultural Life

F O R E W O R D

What is Superluminary Dynamics? What is Superluminary Relativity (SLR)? Why do we need Superluminary Dynamics and Superluminary Relativity? [†]

I will try to offer the answers to these questions.

This book is a report of my research, carried out during the last several years. In the book I propose The Theory for Superluminary Relativity (SLR), based on Superluminary Dynamics and Superluminary Transformation. Superluminary Dynamics is the dynamics of particles in motion with $v > c$. Superluminary Transformation gives the relation between the magnitudes of the frame of reference where $v < c$ only is possible, with the same magnitudes in the frame of reference where $v > c$ is possible. Superluminary Transformation correlates with Galilean and Lorentz transformations. The results of the analysis give a new insight into nuclear forces and structures.

Why do we need Superluminary Dynamics and Superluminary Relativity? Before we answer this question we need to review, at least in brief, the state of nuclear and particle physics, according to recent reports.

It is an extremely difficult task to make a brief but comprehensive review of contemporary nuclear physics. Therefore we shall restrict our review by using only one, nevertheless very relevant and outstanding source: The Rice University, Houston, Texas, USA. [††]

"High Energy and Nuclear and Particle Physics at Rice University work on a wide range of experiments." We shall cite here in brief some of their results and their programme of work, in six items. The crucial terms and parts which are in connection with the new SLR theory presented in this book will be in italics with

[†] Very often in literature, hypothetical phenomena by which in formation can be transmitted at speeds faster than light are called Superluminal, why the term Superluminary is used here instead, is explained in the Appendix of this book.

[††] http://pgsa.rice.edu/physics - Data revised: January 11, 1996 and April 8, 1997. Ref. [22].

the hope that it will better help to elucidate on the main notions of the theory presented in order to answer the question: ”Why do we need Superluminary Dynamics and Superluminary Relativity?”

1. The High Energy group at Rice University is a collaborator on the DO detector at Fermilab which is studying proton-antiproton collisions at the world’s highest energy accelerator. DO and the other large collider experiments at Fermilab, CDF, have recently announced the discovery of the elusive top quark. The Rice group made a significant contribution to that discovery and *is currently deeply involved in an improvement of the mass determination*.

2. The Rice group is heavily involved in one of the two large detectors being constructed - the *Compact Muon Solenoid detector*. They are responsible for building much of the trigger electronics for the *End Cup Muon subsystem*. *The search for new physics will include looking for the Higgs boson, evidence for supersymmetry and unanticipated phenomena.*

3. In 1964 it was shown that in the neutral kaon system the combined symmetry of *charge conjugation and parity (CP)* was not conserved. After 30 years, *the origins and exact nature of CP violation are still not understood*. The Standard Model of particle physics can accommodate CP violation, but the Standard Model also makes specific predictions about the nature and size of CP violation.

4. The RHIC (*Relativistic* Heavy Ion Collider) will also have the capability of accelerating ions of different masses, all the way down to protons. In addition, the *proton beams can be polarized*. From collisions of 250 GeV polarized protons on 250 GeV polarized protons, the STAR (Solenoid Tracker at RHIC) will be in the enviable position of learning about *the spin dependent structure functions of the nucleus* and in particular the fraction of the spin carried by the gluons.

5. A novel cryogenic approach to cooling and trapping helium atoms in long lived (metastable) excited states in a magneto-optic trap. The goal of this research is to examine collisions between excited atoms in the trap and, by turning off the trap and allowing them to fall, their interaction with surfaces. This will enable study of metastable deexcitation at surfaces in the *quantum regime where the atomic deBroglie wavelength is much larger than the range of the atom-surface interaction potential.*

6. The Rice University group is conducting experiments using *atoms in which one electron is excited to a state of large potential quantum number n, up to n~1200. Such atoms possess very unusual physical characteristics*.

The crucial terms and phrases in the first five items are: *improvement of the mass interpretation, muon, exact nature of CP violation, relativity, proton ability to be polarized* and *deBroglie waves*.

Now, we need also in brief, to describe what the main concepts are of the presented Theory for Superluminary Relativity.

The hereby proposed Theory for Superluminary Relativity (SLR) includes the principles of Quantum Mass Theory (QMT) [4] and modified principles of Special and General Relativity. **One of the main concepts of the SLR theory is application of Newton's law of universal gravitation to nuclear structures. The constant in the Newton's gravitational magnitudes for distances and masses characteristic for nuclear structures is defined and determined by the Quantum Mass Theory.** On the basis of the principles of these two theories (SLR and QMT) a new model of the deuteron nucleus is offered. The essential features of this new model are directly connected with crucial terms and phrases of the first five items from contemporary nuclear and particle physics. To explain this, it is also necessary to describe briefly the new model of the deuteron nucleus which is founded on the new concept for nuclear forces and new properties of the vacuum. There are seven main features of the new proposed deuteron nucleus model, described as follows:

A) According to the Superluminary Relativity and Quantum Mass Theory principles, the deuteron nucleus is thought of as a proton-neutron system with two binding particles, emitted and absorbed by the two nucleons. In the analysis presented two possibilities are elaborated on:

a) proton-neutron system with m^+ and m^- *muons*, and,
b) proton-neutron system with π^+ and π^- *mesons*, that is, *pions*.

Nucleons are rotating with tangential velocities,

$$v > c$$

and muons, or pions, are also rotating with velocities,

$$v > c$$

but in the opposite direction of the rotation of the nucleons.
In the current theories muon is not considered as a possible binding particle in the nuclei. However, muon itself could be considered as a nucleus in muonium (Mu), a rather new hydrogen like atom, composed of $\mu^+ e^-$. [18], [19]

In the presented SLR theory muon is considered as a binding particle in the deuteron nucleus, and by that some new properties are attributed to the muon.

B) The particles may achieve the velocities,

$$v > c$$

if they are in the range of space determined by the electron and proton Compton wavelengths, that is the space occupied by nucleons in the nuclei. In this part of the space, *mass properties* of the particles prevail over the electromagnetic properties of the vacuum, and supposition

$$c = constant$$

is no longer valid, and consequently,

$$c' \neq c$$

where c' is the velocity of light in this part of space.

C) The nucleons in the deuteron nucleus are kept at certain distance from each other as a result of the equilibrium of two kinds of forces acting on these particles, that is,

$$F_{attractive} = -F_{repulsive}$$

F_{att} is Newton's gravitational force between the masses of the all participating particles in the system, with gravitational constant for nuclear structures defined by the principles of QMT [4]. The repulsive forces F_{rep} are the sum of the centrifugal forces as a result of the rotation of the particles and the repulsive Coulomb force. By this, is proposed *a new comprehension of the nuclear forces in general*, and *new notions for nuclear structure*, explained in the following items.

D) In the proposed new model of the deuteron nucleus, there is introduced a new concept for *mass determination* and new properties of the vacuum.

E) In the proposed new model there is also introduced *a new concept* for *charge conjugation and parity (CP) conservation*. The charge exchange between the proton and neutron in a system as it is deuteron nucleus, but also when they are free particles (as in scattering phenomena), is of such a nature that Coulomb repulsive force is produced between these nucleons.

F) The ratio of the wavelengths of *deBroglie waves* of muons and nucleons in the deuteron nucleus, shows *resonant effect*, which is not the case when pions are taken as participating particles in this nucleus.

G) There are two main experimental proofs for the new proposed deuteron nucleus:

a) According to the current theories there is a difference between the observed and computed values of the magnetic moment of the deuteron nucleus, which cannot be explained. This difference cannot be considered as a consequence of the systematic errors, neither in the experiments or in computations. The results of the analysis presented, based on the proposed SLR theory, show that the deuteron nucleus, besides the magnetic moments of the proton and neutron, has *its own magnetic moment* as a result of the rotation of the nucleons. The obtained value for this magnetic moment is exactly the same with the difference that cannot be explained by the current theory.

If the deuteron nucleus has *an intrinsic magnetic moment*, then it would be possible to accomplish the *polarization of deuteron nucleus beams*, similarly as already has been achieved and reported *polarization of proton beams*.

b) The proton-neutron scattering phenomena are explained by the principles of SLR and QMT, by applying the new concept for *charge conjugation and parity (CP) conservation*.

As we can see in these seven main features of the new proposed deuteron nucleus model, we can find all crucial terms and phrases from the first five items of contemporary nuclear and particle physics.

We have left the sixth item from the citation of the Rice University report, to be discussed separately. It is stated therein that: ”*when atoms in which one electron is excited to a state of large potential quantum number up to n~1200, such atoms possess very unusual physical characteristics*”.

We have already stated that the new proposed deuteron nucleus model is founded on the principles of SLR and QMT. In the Reference [4], where QMT is presented it is shown that, *if the electron in the hydrogen atom is excited to the state of the potential quantum number,*

$$n = 794$$

then, the electron turns into a positron. The consequence is very unusual: the hydrogen atom turns into a system of one proton and one positron, which is undoubtedly a very *odd example of CP violation*. This has been obtained as a result of theoretical analysis based on the QMT principles. If this is experimentally proven, then ”*atoms with very unusual physical characteristics*” will certainly be obtained and a rather ”exotic regime of matter” could be expected.

It is worthwhile mentioning here the reports for existence of hydrogen - like atoms, besides hydrogen itself [18], [19]: positronium (Ps)- composition of e^+e^-, muonium (Mu) - composition of m^+e^-, m-mesohydrogen - composition of pm^-, and p -mesohydrogen - composition of pp^-. It is obvious that all these rather new atoms are made up of one positively and one negatively charged particle, while the hypothetical proton - positron system is supposed to be made up of two positively charged particles. That is the reason why this system would be the example of very odd CP violation, according to the current theories. In the SLR theory presented here, a new proposed concept for charge conjugation and parity (CP) conservation, offers an alternative approach to the cases of CP violation.

Comparison of the crucial terms and phrases printed in italics and of the contexts where they appear, in the six items from contemporary nuclear particle physics, cited from the Rice University, with those in the seven items of the presented Theory of the Superluminary Relativity, shows, that the SLR theory proposed here correlates with the present state of nuclear and particle physics.

According to the hereby proposed Theory of Superluminary Relativity, nuclear forces are explained by Newton’s gravitational law and Einstein’s General Theory of Relativity, with gravitational constant defined for masses and distances characteristic for nuclear structures, and determined by Quantum Mass Theory.

This contemplation offers only introductory answers to the main question: ”Why do we need Superluminary Dynamics and Superluminary Relativity?” I hope that the comprehensive answer to this question is offered in the material presented in this book.

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C O N T E N T S

P R E F A C E

The Special Theory of Relativity is based on Einstein's main postulate that the velocity of light is the same for all observers in uniform relative motion, i.e., the velocity of light in a vacuum is constant. Very often, in literature this postulate is expressed in two other forms. The velocity of light is the ultimate velocity by which interactions in nature can be transferred, or, the velocity of any particle cannot be larger than the velocity of light in the vacuum, i.e., the following is not possible,

$$v > c \tag{1}$$

The factor,

$$g = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{2}$$

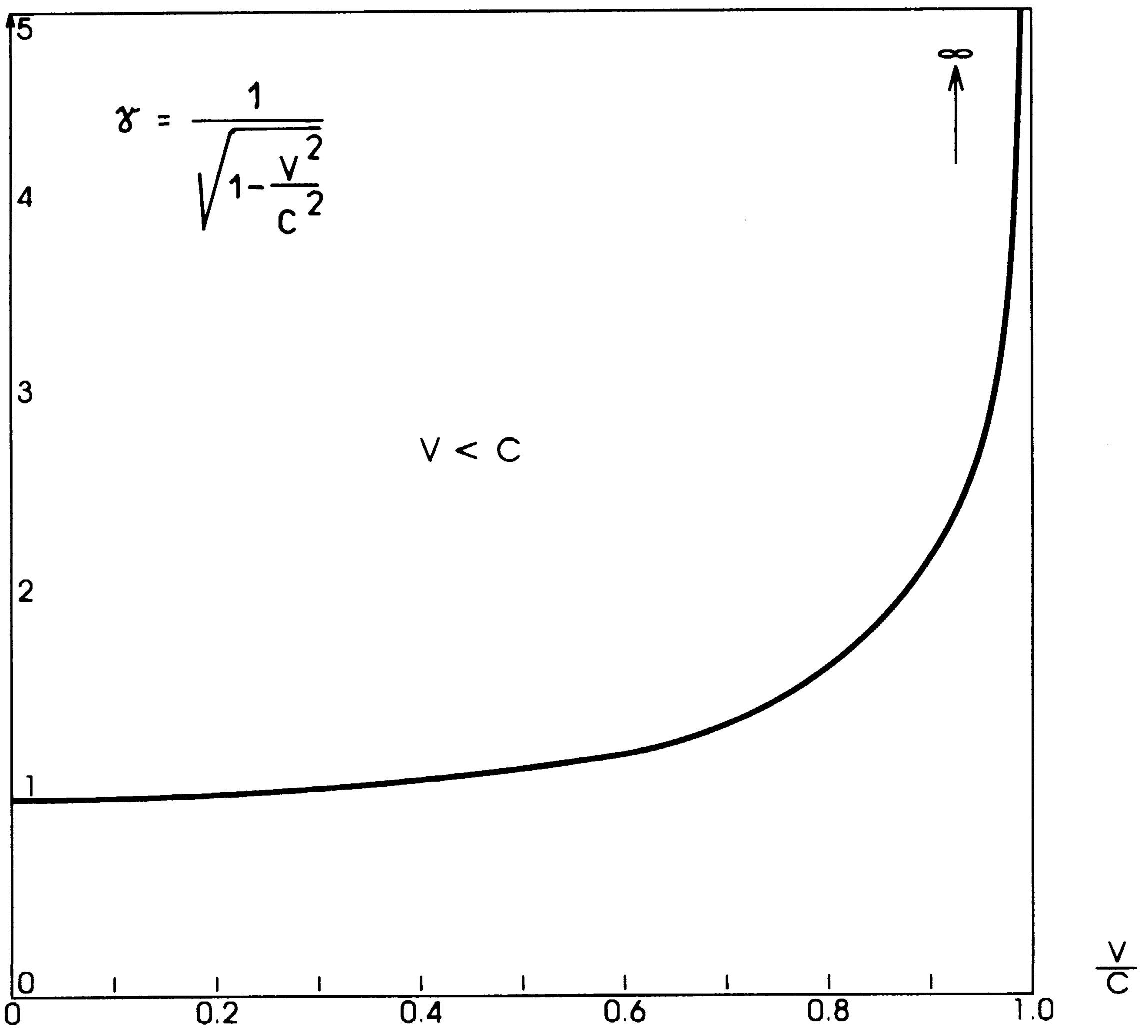
taken from the Lorentz transformation is essential in the formulations of the all important equations in the Theory of Special Relativity [1], [2].

According to the principle of Special Relativity, the presence of bodies, or more specifically, particles does not have any influence on the space-time continuity [1], [2]. In contrast to this, in General Relativity, the presence of bodies in general, and the presence of particles too, have influence in the space-time continuity. In General Relativity, c is not constant [3].

Fig. 1 shows the curve,

$$g = f\left(\frac{v}{c}\right) \tag{3}$$

The diagram shows that for $v = 0$, $g = 1$, and for $v = c$, $g \to \infty$.



<u>Fig. 1</u> The function $g = f\left(\frac{v}{c}\right)$

According to the Special Relativity, the momentum is expressed by the equation,

$$p = \frac{mv}{\sqrt{1-\frac{v^2}{c^2}}} = g\ m v \tag{4}$$

For $v \ll c$, $g = 1$, the last equation turns into the equation for momentum in classical dynamics, i.e.,

$$p = mv \tag{5}$$

One of the main consequences of the principle of Special Relativity is that each particle has energy equivalent to its mass. Thus, a particle with mass *m* will have equivalent energy [1], [2],

$$E_{total} = mc^2 \tag{6}$$

where,

$$m = \frac{m_0\, c^2}{\sqrt{1 - \frac{v^2}{c^2}}} = g\ m_0\, c^2 \tag{7}$$

and m_0 is the rest mass of the particle, which also has equivalent energy,

$$E_0 = m_0\, c^2 \tag{8}$$

called the rest energy of the particle.

The kinetic energy of the particle is defined by the expression,

$$E_{kin} = E_{total} - E_0 \tag{9}$$

or,

$$E_{kin} = m_o\, c^2 \left(\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 1 \right) = m_0\, c^2 \left(g - 1 \right) \tag{10}$$

In all these equations, *c* is the velocity of light in the vacuum, and *v* is the velocity of the particle.

There are two other main consequences in Special Relativity connected with factor g . The first is, contraction of the length of the body which travels with velocity close to *c*, and the second is, subtraction of time for the body in such a motion. These two consequences of the Special Relativity principles in dynamics, will be elaborated on in separate subsections.

In this work, the theory of Special Relativity is fully accepted, with the supposition that it is valid in the region of the space where only $v < c$ is possible. There are many experimental proofs which support the principle of Special Relativity, and by them is justified the main postulate *c = constant*. However, all experimental proofs for the validity of the Special Relativity principle, have not led to the fundamental postulate *c = constant* being accepted as a physical law. It still remains a postulate, i.e., assumption. Justified assumption for the theory of Special Relativity, but still assumption only.

It is worth mentioning here, that factor,

$$g = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$

which is essential in the theory of Special Relativity, is taken from the Lorentz transformation, and has emerged as a result of the quest for vacuum properties or more specifically, from the search for a connection between electromagnetism and vacuum properties. Also it has to be pointed out, that the main postulate for the ultimate velocity of the traveling particles is connected with velocity of light in the vacuum. These two facts show clearly, that the whole theory of Special Relativity is based on a supposition for certain existing properties of the vacuum. All the performed and observed experiments which verify the theory of Special Relativity, also verify the existence of the supposed vacuum properties.

Vacuum properties which are directly connected with the propagation of light in the vacuum, are vacuum permeability,

$$m_0 = 1.2566 \cdot 10^{-6} \ m\,kg\,C^{-2} \tag{11}$$

and vacuum permittivity,

$$e_0 = 8.8544 \cdot 10^{-12} \ \ N^{-1}\,m^{-2}\,C^2 \tag{12}$$

These magnitudes are defined by the phenomena in which the charge is traveling in the vacuum. The photon has no charge, however, the light has electromagnetic properties, and therefore these magnitudes determine the conditions for light propagation in the vacuum.

According to the Maxwell equation, the velocity of light in the vacuum is,

$$c = \frac{1}{\sqrt{m_o\, e_o}} \tag{13}$$

This explicitly shows the connection between electromagnetic vacuum properties and principles of Special Relativity.

It is interesting that vacuum properties are determined and connected only by the properties of the charged particles, and consequently are only determined electromagnetic properties of the vacuum. The fact that particles which travel through the vacuum have another property, i.e., mass an important property and magnitude which expresses that property, is completely neglected.

Our stand point is that the vacuum should have properties which are connected with the mass of the particles, as well. The Ref. [4], elaborates on such properties of the vacuum.

The main supposition of the theory for Superluminary Relativity (SLR) presented here, is that besides the vacuum properties covered by the Special Relativity and corresponding observed phenomena, there exist some other vacuum properties as well, which are additional to the first ones, but which allow the possibility for $v > c$.

For the region of the space, where vacuum properties allow $v > c$, Special Relativity concepts will be extended by modifying the main factor g into g ' [5]. According to this, the assumption for $v < c$, and all the consequences of that in Special Relativity are valid only in the range of the space where certain vacuum properties prevail, while, in the region of the space where some other vacuum properties are dominant, $v > c$ should be possible. This will have important consequences for the main physical laws which are conservation laws. The starting assumption in this work is that conservation laws should be preserved in this new frame of reference.

The region where factor g is valid, will be called system g, and region where factor g ' is valid, will be called system g '.

Our main task is to try to formulate one of the most important laws in physics, the energy conservation law, in a space where $v > c$ is possible, and to find the connection between two regions of the space, where different vacuum properties are prevailing. Our task is also to find the magnitudes which will determine the vacuum properties of this new region of the space.

The results of the analysis justify the validity of these newly offered hypotheses and suggest performing experiments which will support the theory and analysis presented.

I. INTRODUCTION

1. THE SPECIAL THEORY OF RELATIVITY†

1.1 Einstein's principle of Special Relativity

In 1905 Albert Einstein proposed a theory which completely altered essential notions of space and time in science. Einstein based his Special Theory of Relativity on two postulates, [1], [2], [6-10],

1. The principle of relativity: All the laws of physics are the same in all inertial reference frames.

2. The speed of light is constant. The speed of light in a vacuum has the same value,

$$c = 3 \cdot 10^8 \ m/s \tag{14}$$

in all inertial frames of reference, regardless of the velocity of the observer, or the velocity of the source emitting the light.

The first postulate asserts that all the laws of physics are the same in all reference frames moving with constant velocities relative to each other. This postulate could be considered as a generalization of the principle of Newtonian relativity that refers only to the laws of mechanics. According to this postulate there is no preferred inertial reference frame, and it is not possible to detect absolute motion.

The postulate 2, for the constancy of the speed of light, is required by postulate 1. If the light velocity is not constant in all inertial frames, it would be

† In order to present as concisely as possible the Special Relativity in this introductory section besides Einstein's original works [1], [2] and his book with Lorentz, Minkowski and Weyl [6], the Physics textbooks [7], [8], [9] and [10] have been used.

possible to distinguish between inertial frames and a preferred, absolute frame could be identified, in contradiction to postulate 1 [10].

In the theory presented here for Superluminary Relativity, we shall have the opportunity to elaborate this postulate more thoroughly, but with other alternative notions.

1.2 The Lorentz transformation

For the application of Einstein's two postulates in physics, Galilean transformation equations cannot be correct any more.

Fig. 2 shows two coordinate systems S and S'. We assume that observers O and O' are moving with relative velocity *v* and that X- and X'- axes point in

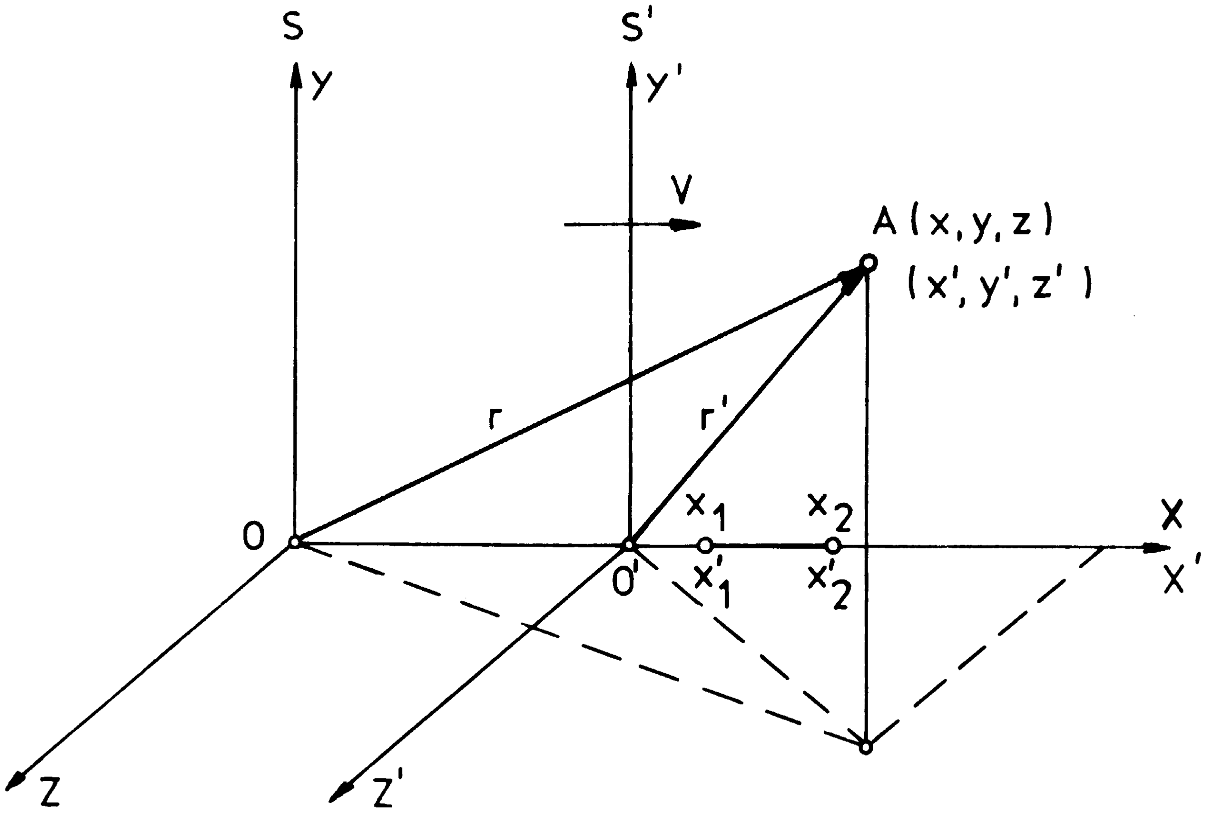


Fig. 2 Frames of reference S and S' in uniform relative translational motion.

the direction of their relative motion and the axes YZ and Y'Z' are parallel. We shall also assume that both observers set their clocks so that,

$$t = t' = 0 \tag{15}$$

when O and O' coincide.

The position of the point A in the system S is determined by the equation,

$$x^2 + y^2 + z^2 = r^2 \tag{16}$$

or,

$$x^2 + y^2 + z^2 = c^2 t^2 \tag{17}$$

and in the system S', by the equation,

$$x'^2 + y'^2 + z'^2 = r'^2 \tag{18}$$

or,

$$x'^2 + y'^2 + z'^2 = c^2 t'^2 \tag{19}$$

Under these described conditions, the new transformation compatible with the assumption for the constancy of the speed of light, is, [1], [2]

$$x' = \frac{x - vt}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{20}$$

$$y' = y \tag{21}$$

$$z' = z \tag{22}$$

$$t' = \frac{t - \frac{vx}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{23}$$

Einstein obtained these transformation equations, in this form, in 1905 and he called them *Lorentz transformation* [1], [2], [6], [7-10].

These equations in another form, were originally obtained by Lorentz in the quest for the electromagnetic properties of a vacuum, connected with the problem of the electromagnetic field of a moving charge [7-10].

Fig. 1 shows the change of the factor,

$$g = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{24}$$

with *v/c*.

For most measurements in the macroworld, there is no difference between Lorentz and Galilean transformations because for

$$v \ll c \tag{25}$$

the factor g is,

$$g = 1 \tag{26}$$

this is evident from the diagram in Fig. 1.

The inverse Lorentz transformation expresses the coordinates X, Y, Z and t measured in terms of the coordinates X', Y', Z' and t' measured by O'. The set of relations of inverse Lorentz transformation is,

$$x = \frac{x' + vt'}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{27}$$

$$y = y' \tag{28}$$

$$z = z' \tag{29}$$

$$t = \frac{t' + \frac{vx'}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{30}$$

1.3 <u>Velocities transformation</u>

The Lorentz transformation of velocities is,

$$V' = \frac{V - v}{1 - \frac{vV}{c^2}} \tag{31}$$

where,

$$V = \frac{dx}{dt} \tag{32}$$

is the velocity of A measured by O, along direction X, and,

$$V' = \frac{dx'}{dt'} \tag{33}$$

is the velocity of A measured by O' also along direction X'. It has to be pointed out that *dt* and *dt'* are used here because *t* and *t'* are not same.

For,

$$v \ll c \tag{34}$$

Equation (31) reduces to the Galilean transformation of velocities, that is,

$$V' = V - v \tag{35}$$

However, a very important consequence appears when it is supposed that,

$$V = c \tag{36}$$

because then,

$$V' = \frac{c - v}{1 - \frac{vc}{c^2}} = c \tag{37}$$

Hence, the conclusion is that observer O' also measures a velocity *c*, despite the relative velocity *v* of the frame of reference S'.

The inverse Lorentz velocity transformation is given by the next equation,

$$V = \frac{V' + v}{1 + \frac{v V'}{c^2}} \tag{38}$$

where *V* and *V'* are defined as in Equation (31).

The latter equation gives the velocity, relative to O, of an object moving with velocity *V'* relative to O', which in turn is moving with velocity *v* relative to O.

1.4 Length contraction

We shall use Fig. 2 again. Two frames of reference are presented, where axes YZ and Y'Z' are parallel, and the X- and X'- axes point in the direction of their relative motion. The main assumption is that both observers, O and O' measure certain length simultaneously. Consider a bar at rest relative to O' and parallel to the X'-axis. For the observer O' the length of this bar is,

$$L' = x'_b - x'_a \tag{39}$$

The observer O who measures the length of the same bar has to do these measurements at the same time as observer O' measures the length of the bar. However, for the observer O the bar is in motion, and he will measure coordinates x_a and x_b at the same time as the observer O' is taking the measurement. The observer O will find that the length of the bar is,

$$L = x_b - x_a \tag{40}$$

If the Lorentz transformation Equation (20) is applied here, then the following will be obtained,

$$L = \frac{1}{g} L' = \sqrt{1 - \frac{v^2}{c^2}} L' \tag{41}$$

Because the factor,

$$\frac{1}{g} = \sqrt{1 - \frac{v^2}{c^2}} \tag{42}$$

is less than unity, it is obvious that,

$$L < L' \tag{43}$$

From the latter expression, we may conclude that the length of a body is measured to be shorter when the body is in motion, relative to the observer than when the body is at rest, relative to the observer, i.e.,

$$L_{motion} < L_{rest} \tag{44}$$

The length of a body at rest relative to an observer is called the proper length of the body.

1.5 Time dilation

Let us consider two events that occur at times t'_a and t'_b but at the same place x' relative to an observer O' in motion with respect to O. Relative to O the events occur at different places and times t_a and t_b respectively.

Applying the Equation (30) of the inverse Lorentz transformation, to both events, finally we obtain,

$$T = g\ T' \tag{45}$$

or,

$$T = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} T' \tag{46}$$

Thus, we may conclude,

$$T_{motion} > T_{rest} \tag{47}$$

or, processes appear to take a longer time when they occur in a body in motion relative to the observer than when the body is at rest relative to the observer.

The time interval between two events occurring at points at rest relative to an observer is called the proper time interval.

1.6 Relativistic energy

To derive the relativistic equation for the work-energy theorem, we shall start with the definition of the work done on a particle by a force *F* and use the definition of relativistic momentum.

Particle in motion with mass *m* and velocity *v* has a momentum,

$$p = mv \tag{48}$$

while the relativistic momentum of the same particle with same velocity is,

$$p = m_0\, v g \tag{49}$$

or,

$$p = \frac{m_0\, v}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{50}$$

Now, we may write the equation for the work done on the particle by the force *F*,

$$W = \int_{x1}^{x2} F\, dx \tag{51}$$

because,

$$F = \frac{dp}{dt} \tag{52}$$

the relativistic force is,

$$F = \frac{d}{dt}\frac{m_0\, v}{\sqrt{1-\dfrac{v^2}{c^2}}} = \frac{m_0\left(dv/dt\right)}{\left(1-\dfrac{v^2}{c^2}\right)^{\frac{3}{2}}} \tag{53}$$

Substituting this expression for *dp/dt* and,

$$dx = v\, dt \tag{54}$$

into Equation (51) we obtain,

$$W = \int_{x1}^{x2} \frac{m_0\left(dv/dt\right) v\, dt}{\left(1-\dfrac{v^2}{c^2}\right)^{\frac{3}{2}}} = m_0 \int_0^v \frac{v}{\left(1-v^2/c^2\right)^{\frac{3}{2}}}\, dv \tag{55}$$

which assumes that the particle is accelerated from rest to some final speed *v*. Evaluating the integral, we find that,

$$W = \frac{m_0\, c^2}{\sqrt{1-\dfrac{v^2}{c^2}}} - m_0\, c^2 \tag{56}$$

or,

$$W = m_0\, c^2 \left[\frac{1}{\sqrt{1-\dfrac{v^2}{c^2}}} - 1\right] \tag{57}$$

Because the work done by a force acting on a particle is equal to the change of the kinetic energy, and the initial kinetic energy is zero (since at the beginning of the process, the particle was at rest), we conclude that the work *W* is equivalent to the relativistic kinetic energy E_k , [1], [2], [6], [7-10],

$$E_k = m_0\, c^2 \left(g - 1\right) \tag{58}$$

that is,

$$E_k = m_0 c^2 \left[\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 1 \right] \tag{59}$$

In the experiments with high-energy particle accelerators this equation is confirmed.

Consequently, the total energy of the particle in Special Relativity, is defined by the expression,

$$E = g\ m_0 c^2 = E_k + m_0 c^2 \tag{60}$$

or,

$$E = \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{61}$$

and the rest energy of the particle is,

$$E_o = m_o c^2 \tag{62}$$

when the particle is at rest, i.e., $v = 0$.

It is worthwhile mentioning that the total energy of the particle, as it is defined here, includes kinetic energy and rest energy, but not the potential energy.
Equation (62) suggests two important conclusions: firstly, to each mass m is associated an energy E; secondly, an energy E is associated with a mass m.

Finally, we may conclude that any change of the energy ΔE, is associated with change in mass Δm, and conversely, what is given by the next expression,

$$\Delta E = (\Delta m) c^2 \tag{63}$$

2. THE GENERAL THEORY OF RELATIVITY

In 1916, Einstein published his work ”The Fundamentals of General Relativity” [3], eleven years after he published his theory of Special Relativity [1], [2]. In 1954, he published a work in which he explains the differences and connections between Special and General Relativity [11]. In this work he gives the exact formulation of General Relativity.

Before we present in brief the main concepts of this work of Einstein, let us remind ourselves of the two postulates of General Relativity:

1. The laws of physics must be of such a nature that they apply to reference systems in any kind of motion relative to the mass distribution of the universe.

2. The principle of equivalence. All bodies at the same place in a gravitational field experience the same acceleration.

The first postulate is adopted in our theory, of Superluminary Relativity presented here, therefore we need to elaborate on it at least briefly. To do that we shall return now to Einstein's work from 1954 [11].

According to Einstein, instead of referent body, the Gaussian coordinate system should be used. Einstein States: ”To the fundamental idea of the principle of General Relativity corresponds the next statement: *all Gaussian coordinate systems are equally valid for formulations of the general laws of nature*” [11].

Furthermore, Einstein states: ”The Special Theory of Relativity is valid for Galilean ranges, which means for ones, where a gravitational field is absent. The Galilean referent body is used as a referent body, that is the same rigid body with such a chosen state of motion relative to it, so that the Galilean postulate for uniform, straight-lined motion of *an individual* material point, is valid. However, in gravitational fields there are not rigid bodies with Euclidean properties; the notion of rigid referent bodies has no application in the General Relativity. The gravitational fields influence the work of the clocks in such a way that physical definition of time strictly by the clock is no longer so evident as in the Special Theory of Relativity” [11]. This is the main reason why the Gaussian four-dimensional system is more convenient for the General Theory of Relativity, and consequently, *the laws of nature should not be dependent on the chosen frame of reference*. This is exactly what we would like to prove by the Superluminary Theory proposed here.

The first postulate of General Relativity, and Einstein's explanation of it, is very important for the Superluminary Relativity we propose here.

The second principle of the general relativity, the principle of equivalence, explains whether, there is a difference between the two properties of mass: *a gravitational attraction* for other masses, and an *inertial* property that resists acceleration. To designate these two attributes we use the subscripts *g* and *i*, and write,

Gravitational property: $$F_g = m_g\, g \qquad (64)$$

Inertial property : $$F_i = m_i\, a \qquad (65)$$

The value for the gravitational constant *G* was chosen to make the magnitudes m_g and m_i numerically equal. Regardless of how *G* is chosen, however, the strict equality of m_g and m_i has been measured to an extremely high degree. Thus, it appears that gravitational mass and inertial mass may indeed be exactly equal [10].

As a contrast to the Special Relativity concept that the presence of any kind of bodies does not influence the properties of space and time, according to General Relativity, the presence of bodies influences the space-time continuity. In Section V space-time curvature in General Relativity and in the Superluminary Relativity is elaborated on.

Part of the theory of general relativity, which is of particular interest to us, is the propagation of light in the gravitational field.

The velocity of light in the gravitational field is [3],

$$c' \approx c\left(1-\frac{2Gm}{r\,c^2}\right) \tag{66}$$

where,

$$G = 6.67\cdot 10^{-11}\ Nm^2\ kg^{-2}$$

is the gravitational constant, and g is the distance from the centre of the body with mass m, and the point where the light velocity is observed.

The deflection of the light from its direction of propagation is given by the equation [3],

$$a = \frac{4G\,m}{r\,c^2} \tag{67}$$

For the case when the light of a certain star is passing close to the surface of the sun, Einstein has computed the deflection of the light,

$$a = 1.7'' \tag{68}$$

This has been verified during the observation of an eclipse of the sun in 1919, when the following values were measured [11], [12],

$$a = 0.8'' \tag{69}$$

and

$$a = 1.8'' \tag{70}$$

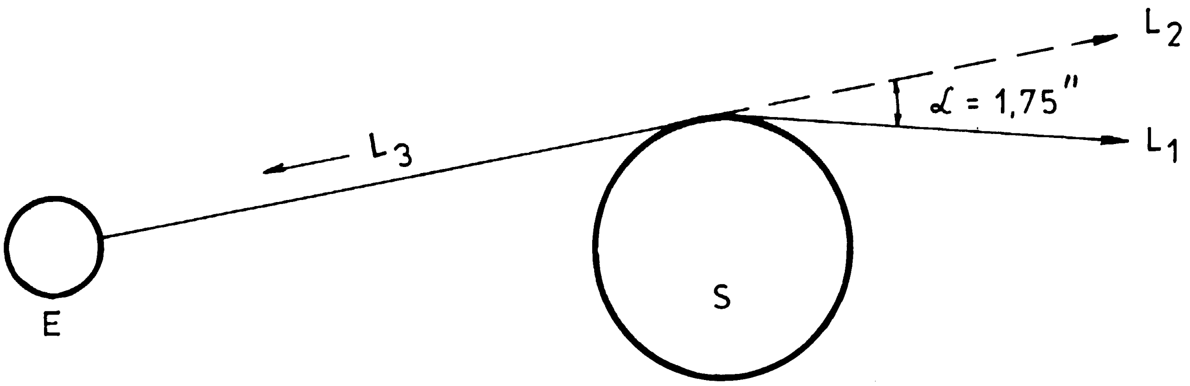


Fig. 3 Deflection of starlight passing near the Sun. E - Earth, S - Sun, $\alpha = 1.75''$ is the angle of the starlight deflection, L_1 - is the actual direction to the star, L_2 - is the apparent direction to the star, L_3 - the deflected path of the light from the star.

Fig. 3 shows the deflected path of the light from the star passing close to the surface of the sun.

According to Einstein explanation, half of this deflection is caused by the mass interaction between the sun and the passing photons of the light, and half of it is by the space-time curvature [11], [12], [13].

II. THE SUPERLUMINARY FRAME OF REFERENCE

1. PRINCIPLES OF SUPERLUMINARY RELATIVITY

The theory of Superluminary Relativity is based on the following principles:

Principle 1. The laws of physics must be of such a nature that they apply to reference systems in any kind of motion, relative to the mass distribution of the universe. That is, the laws of nature are the same for all free moving observers independent of their velocity.

Principle 2. The presence of bodies in general has influence in space-time continuity.

Principle 3. There is equivalency between particles' masses and their energies.

Principle 4. The speed of light in a vacuum relative to an observer is not constant, i.e.,

$$c \neq constant \tag{71}$$

The speed of light in a certain region of space depends on the vacuum properties, which prevail in that region. If the electromagnetic properties are dominant, the speed of light is constant, and its value is,

$$c = 3 \cdot 10^8 \ m/s \tag{72}$$

If the mass properties of the particles and bodies in general, are dominant in the vacuum of a certain region of space, then the speed of the light is,

$$c' \neq c \tag{73}$$

<u>*Principle 5.*</u> The speed of the particles can be larger than the speed of light in the vacuum described by the Principle 4, that is,

$$v > c \tag{74}$$

and also,

$$v > c' \tag{75}$$

<u>*Principle 6.*</u> Real magnitudes in the frame of reference S' with relative velocity,

$$v > c$$

to the frame of reference S, are virtual magnitudes for the observer O in the frame of reference S. There is a constant M_c which connects the magnitudes of these two frames of reference, S' and S, and which determines the region of the space where the mass properties of the vacuum are prevailing. The virtual magnitudes in the system S, which the constant M_c turns into the real ones, satisfies Principle 1, that is, the energy conservation law is preserved.

2. SUPERLUMINARY TRANSFORMATION

As we have seen in the subsection I/1.1, the Galilean transformation had to be replaced by the Lorentz transformation, so that the speed of light is invariant or independent of the relative motion of the observers. In particular, because the assumption

$$t' = t \tag{76}$$

can no longer be correct. In the Lorentz transformation the time is,

$$t' \neq t \tag{77}$$

Since we have made another, also fundamental assumption,

$$v > c$$

it is necessary, to determine the corresponding transformation.

Fig. 4 shows two coordinate systems, S and S', where the axes YZ and Y'Z' are parallel, and axes X and X' coincide and point in the direction of their relative motion. We shall assume that both observers, that is, in O and O' set their clocks so that, it is,

$$t = t' = 0 \tag{78}$$

when they start to observe the mutual motion of their systems.

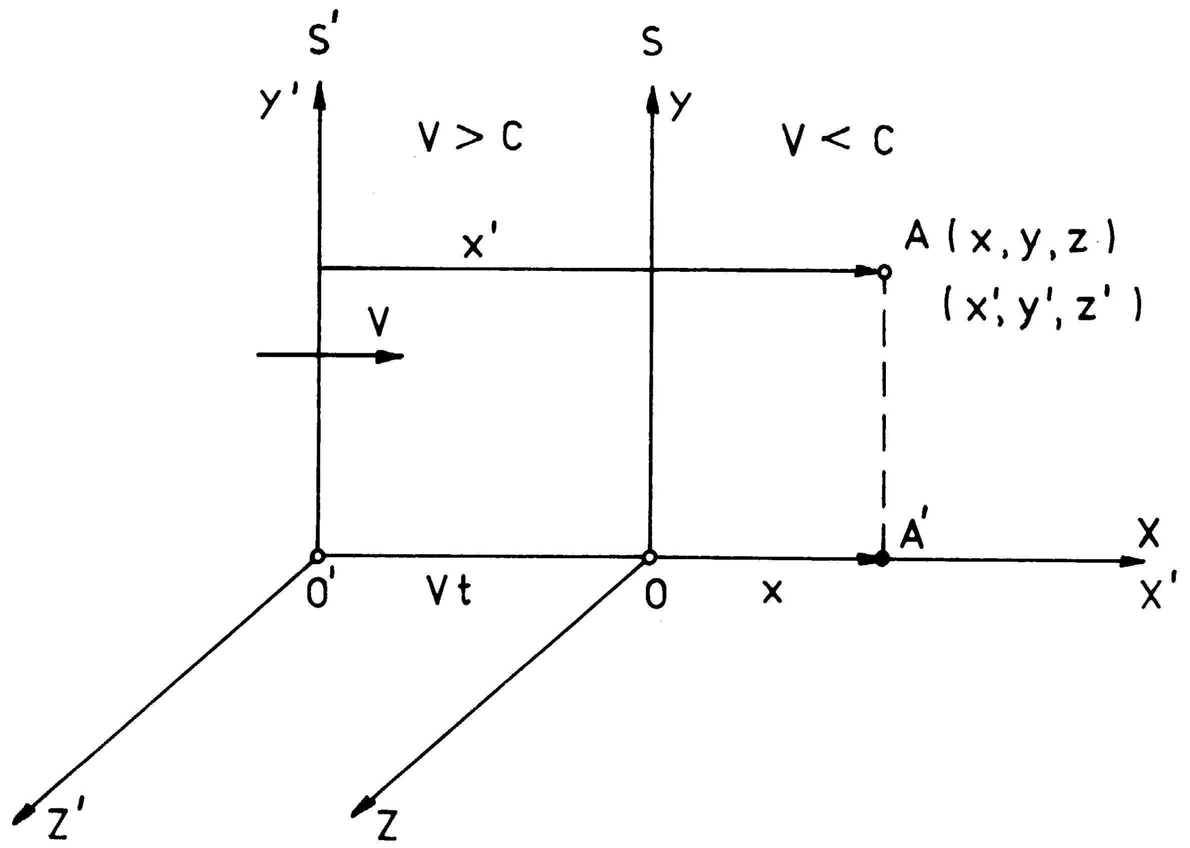


Fig. 4 The frames of reference S and S' in relative translational motion. In the frame of reference S, Lorentz transformation and Special Relativity principles are valid. In the frame of reference S' superluminary transformation and SLR principles are valid.

As is shown in Fig. 4, the system S’ is approaching the system S with relative velocity,

$$v > c \tag{79}$$

Let us assume that, at the time,

$$t = t' = 0 \tag{80}$$

a flash of light with velocity *c* is emitted from the origin O in the system S, towards the point A’, and simultaneously at the same moment, a flash of light with velocity *c'* is emitted from the origin O' in the same direction of propagation with the light from the origin O. Because we assume that in the system S',

$$c \neq constant \tag{81}$$

the resultant velocity of the light emitted from the origin O' will be,

$$c_r = v + c' \tag{82}$$

where *c'* is the velocity of light in the system S'.

Since for the point A,

$$x^2 + y^2 + z^2 = r^2 \tag{83}$$

we may write for the system S,

$$x^2 + y^2 + z^2 = c^2 t^2 \tag{84}$$

For the same point A, we may write the equation for system S',

$$x'^2 + y'^2 + z'^2 = v^2 t^2 \tag{85}$$

where,

$$v > c \tag{86}$$

Hence, now it is necessary to determine new transformation equation which will connect the system S where

$$v < c \tag{87}$$

with system S' where

$$v > c$$

is possible.

Thus, our task is to obtain a transformation relating Equations (20) and (23). The symmetry of the problem suggests that,

$$y' = y \tag{88}$$

and,

$$z' = z \tag{89}$$

Since we have two simultaneously flashed lights from both origins, i.e., O and O’, it has to be taken that the observer at the point A’ will conclude that both lights have reached the point A’ at the same moment, when system S’ will reach the distance *x’* from the point A’. This suggests making,

$$x' = g\,'\left(x + vt\right) \tag{90}$$

where *g ’* is a constant to be determined. We may also assume that,

$$t' = a\left(t + bx\right)$$

where *a* and *b* are constants also to be determined.

To solve the latter two equations so that the results obtained will satisfy Equations (84) and (85), we have to make the next important supposition,

$$g\,' = \sqrt{1 - \frac{c^2}{v^2}} \tag{91}$$

in such a case,

$$a = \frac{1}{g\,'} = \frac{1}{\sqrt{1 - \frac{c^2}{v^2}}} \tag{92}$$

and for *b*

$$b = \sqrt{\frac{c^2\left(v^2 - c^2\right)}{v^4}} \tag{93}$$

is obtained.

The expressions obtained for *g ’*, *a* and *b*, satisfy Equations (84) and (85) so that,

$$v > c$$

is possible.

Thus, we have obtained the superluminary transformation equations,

$$x' = \sqrt{1 - \frac{c^2}{v^2}}\left(x + vt\right) \tag{94}$$

$$y' = y \tag{95}$$

$$z' = z \tag{96}$$

$$t' = \frac{1}{\sqrt{1-\frac{c^2}{v^2}}}\left[t + \sqrt{\frac{c^2\left(v^2 - c^2\right)}{v^4}}\; x\right] \tag{97}$$

3. THE CONSEQUENCES OF SUPERLUMINARY TRANSFORMATION

3.1 Length dilation

If the length of an object at rest in the system S’ is,

$$L' = x'_b - x'_a \tag{98}$$

then applying the superluminary transition Equation (94) the latter equation becomes,

$$L' = \sqrt{1-\frac{c^2}{v^2}}\left(x_b + vt\right) - \sqrt{1-\frac{c^2}{v^2}}\left(x_a + vt\right)$$

or,

$$L' = \sqrt{1-\frac{c^2}{v^2}}\left(x_b - x_a\right) \tag{99}$$

Because,

$$L = x_b - x_a$$

Equation (99) becomes,

$$L' = \sqrt{1-\frac{c^2}{v^2}}\; L$$

or,

$$L = \frac{1}{\sqrt{1-\frac{c^2}{v^2}}}\, L' \tag{100}$$

The length of a body is measured as being longer when the body is in motion, with velocity $v > c$ relative to the observer, than when the body is at rest relative to the observer.

The length of a body at rest relative to an observer is called proper length of the body.

3.2 Time contraction

By the analogy with Equation (45), we may write the expression which connects the time T in the system g , with time T' in the system g'. Hence,

$$T = g'\,T' \tag{101}$$

or,

$$T = \sqrt{1 - \frac{c^2}{v^2}}\,T' \tag{102}$$

what shows that,

$$T < T' \tag{103}$$

The process needs a shorter time when it occurs in a body in motion, with velocity $v > c$ relative to the observer than when the body is at rest, relative to the observer.

The Equation (102) shows that one second in the system g', corresponds,

$$\sqrt{1 - \frac{c^2}{v^2}} \text{ seconds}$$

in the system g .

3.3 Velocities transformation

Assume the body in system S' is in motion with velocity,

$$u'_x = \frac{dx'}{dt'} \tag{104}$$

where,

$$dx' = g\,'\left(dx + v dt\right) \tag{105}$$

and

$$dt' = \frac{1}{g\,'}\left(dt + \Delta t\, dx\right) \tag{106}$$

where,

$$\Delta t = \sqrt{\frac{c^2\left(v^2 - c^2\right)}{v^4}} \tag{107}$$

then,

$$u'_x = \frac{dx'}{dt'} = g\,'^2\,\frac{\dfrac{dx}{dt} + v}{1 + \Delta t\,\dfrac{dx}{dt}} \tag{108}$$

since,

$$\frac{dx}{dt} = u \tag{109}$$

it follows,

$$u'_x = \left(1 - \frac{c^2}{v^2}\right)\frac{u + v}{1 + \Delta t\, v} \tag{110}$$

or finally,

$$u'_x = \left(1 - \frac{c^2}{v^2}\right)\frac{u + v}{1 + \sqrt{\dfrac{c^2\left(v^2 - c^2\right)}{v^4}}\,u} \tag{111}$$

Fig. 4 shows that v is velocity of the system S'.
For $v = c$, the latter expression yields,

$$u'_x = 0 \tag{112}$$

but for $v > c$, the same expression gives,

$$u'_x = u + v \tag{113}$$

If $u = c$, the latter equation yields,

$$u'_x = v + c \tag{114}$$

Supposing that the light velocity in the system S' might be different from its velocity in the system S, then the latter expression becomes,

$$u'_x = v + c' \qquad (115)$$

where *c'* is the velocity of light in the frame of reference S'. In the following analysis is shown that

$$c' < c$$

3.4 Superluminary relativistic energy

To determine the kinetic energy, total energy and rest energy of the particle in the superluminary frame of reference S' we shall use two approaches, and we shall obtain two sets of equations for these magnitudes. The computation for certain examples will show that they are compatible. First we shall define the expressions for these magnitudes using the same approach as the one in the Special Relativity, and after that we shall try by analogy to use the final equations from the Special Relativity, simply by replacing the factor *g* with the factor *g* '.

We shall derive the superluminary relativistic equation for the work-energy theorem, starting with same definition of the work done on a particle by a force, and use the definition of superluminary relativistic momentum, similarly as has been done with the Special Relativity. So obtained magnitudes will have subscript 1.

Particle in motion with mass *m* and velocity *v* in the superluminary frame of reference, will have the momentum,

$$p' = m_0 v g' \qquad (116)$$

or,

$$p' = m_0 v \sqrt{1 - \frac{c^2}{v^2}} \qquad (117)$$

The work done on the particle by superluminary relative force, is,

$$W' = \int_{x'1}^{x'2} F' dx' \qquad (118)$$

where,

$$F' = \frac{dp'}{dt'} \qquad (119)$$

is the superluminary force.

To derive the equation for work done on the particle by superluminary force *F'*, it is important to have in mind that in the system *g* ', according to SLR theory, it is,

$$m = m_0 \sqrt{1 - \frac{c^2}{v^2}}$$

or,

$$m = f(v) \tag{120}$$

Hence, Equation (119) becomes,

$$F' = \frac{dp'}{dt'} = \frac{d(mv)}{dt'} = m\frac{dv}{dt'} + v\frac{dm}{dt'} \tag{121}$$

therefore,

$$F'\,dx' = m\frac{dx'}{dt'}dv + v\frac{dx'}{dt'}dm \tag{122}$$

or,

$$F'dx' = m\,v\,dv + v^2\,dm \tag{123}$$

Thus, Equation (118) becomes,

$$W' = \int m\,v\,dv + \int v^2\,dm \tag{124}$$

Since,

$$dm = \frac{m_o}{2\sqrt{1 - \frac{c^2}{v^2}}}\left(-\frac{c^2}{v^3}\right)dv \tag{125}$$

or,

$$dm = -\frac{m_o\,c^2}{2\,v^3}\frac{dv}{\sqrt{1 - \frac{c^2}{v^2}}} \tag{126}$$

Equation (123) becomes,

$$W' = \int m_o \sqrt{1 - \frac{c^2}{v^2}}\, v\, dv + \int v^2 \left(- \frac{m_o\, c^2}{2 v^3 \sqrt{1 - \frac{c^2}{v^2}}} \right) dv \tag{127}$$

or,

$$W' = m_o \int \sqrt{v^2 - c^2}\; dv - \frac{m_o\, c^2}{2} \int \frac{dv}{v \sqrt{1 - \frac{c^2}{v^2}}} \tag{128}$$

After solving the integrals the latter equations yields,

$$W' = \frac{m_o\, v^2}{2} \sqrt{1 - \frac{c^2}{v^2}} - m_o\, c^2 \ln\left[v \left(1 + \sqrt{1 - \frac{c^2}{v^2}} \right) \right] + \textit{ constant} \tag{129}$$

For the domain *c* - *v*, where *v* > *c*, final expression for *W'* is obtained, that is,

$$W' = m_0\, c^2 \left\{ \frac{1}{2} \sqrt{1 - \frac{c^2}{v^2}} - \ln\left[v \left(1 + \sqrt{1 - \frac{c^2}{v^2}} \right) \right] + \ln c \right\} \tag{130}$$

It is very important to emphasise that in the Special Relativity *W*, defined by Equation (56), there is relative kinetic energy of the particle, equal to the work done by a force acting on a particle. Here, **Equation (130) gives the superluminary relative energy of the particle as a result of the work done by the superluminary relative force given by Equation (119), on the particle, to bring it, from the state with velocity *c* to the state with velocity,**

$$v > c \tag{131}$$

Thus, Equation (130) gives the kinetic energy of the particle in the superluminary frame of reference S', therefore we may write,

$$E_{(kin)1} = m_0\, c^2 \left\{ \frac{1}{2} \sqrt{1 - \frac{c^2}{v^2}} - \ln\left[v \left(1 + \sqrt{1 - \frac{c^2}{v^2}} \right) \right] + \ln c \right\} \tag{132}$$

Then, the total energy would be,

$$E'_{(total)1} = E'_{(kin)1} + E'_{01} \tag{133}$$

where,

$$E'_{01} = m_o\ c^2 \tag{134}$$

is the rest energy of the particle, the same as in the Special Relativity.

The meaning of E_{kin} and E_{total} in the SLR theory, will be defined according to the principles and assumptions of this theory.

As has been stated already at the beginning of this subsection, we shall try to obtain energy equations by two approaches. Therefore, let us remind ourselves what the equations are for the kinetic energy, total energy and rest energy of the particle in Special Relativity.

The kinetic energy is given by the expression,

$$E_{(kin)} = m_o\ c^2 (g\ - 1) \tag{135}$$

or,

$$E_{(kin)} = m_o\ c^2 \left(\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 1 \right) \tag{136}$$

The total energy of the particle is,

$$E_{(total)} = m_o\ c^2 g \tag{137}$$

or,

$$E_{(total)} = \frac{m_o\ c^2}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{138}$$

and the rest energy of the particle is,

$$E_o = m_o\ c^2 \tag{139}$$

Substituting the factor g by the factor g ’ in Equations (135), (137) from the Special Relativity, we shall obtain the energy equations in the Superluminary Relativity. So the energy magnitudes obtained will have subscript 2.

Thus, the total energy in the Superluminary Relativity will be,

$$E'_{(total)2} = mc^2 \tag{140}$$

where,

$$m = m_o \gamma\,' \tag{141}$$

then,

$$E'_{(total)2} = m_o\, c^2 \gamma\,' \tag{142}$$

or,

$$E'_{(total)2} = m_o\, c^2 \sqrt{1 - \frac{c^2}{v^2}} = m_o c^2 - E_{(kin)2} \tag{143}$$

and the rest energy is the same, i.e.,

$$E'_{01} = E'_{02} = E_0 = m_o\, c^2 \tag{144}$$

Because,

$$\gamma\,' < 1$$

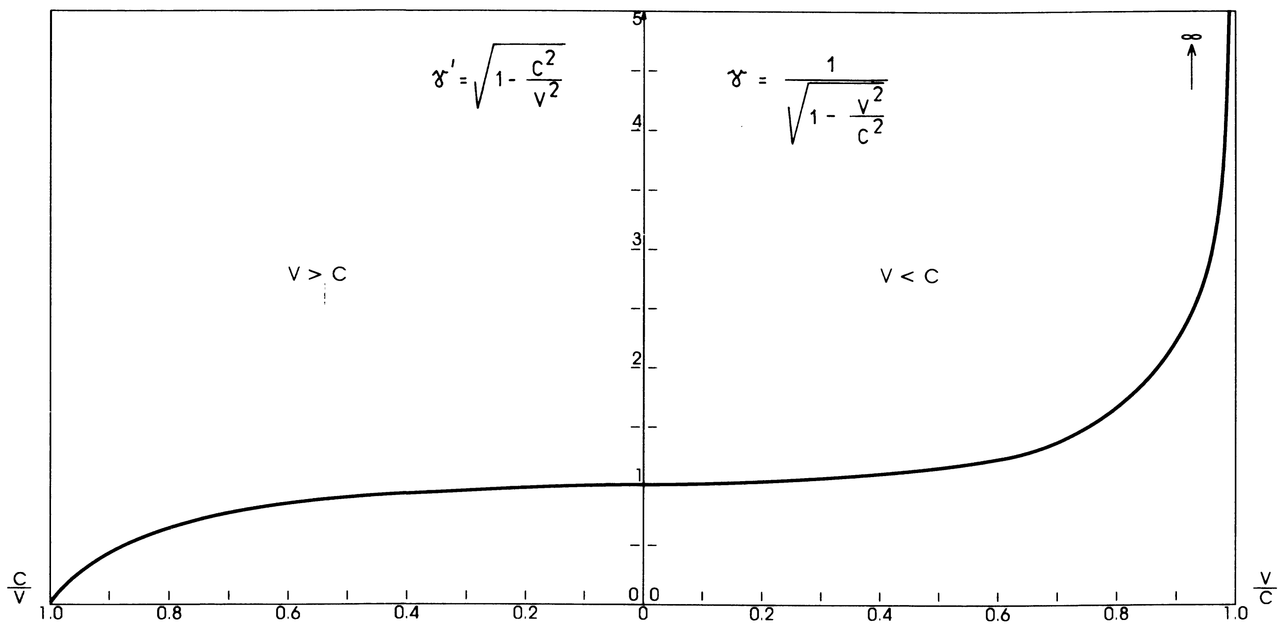


Fig. 5 Functions $\gamma\,' = f\left(\frac{c}{v}\right)$ and $\gamma = f\left(\frac{v}{c}\right)$ with common ordinate and common O points of the axes.

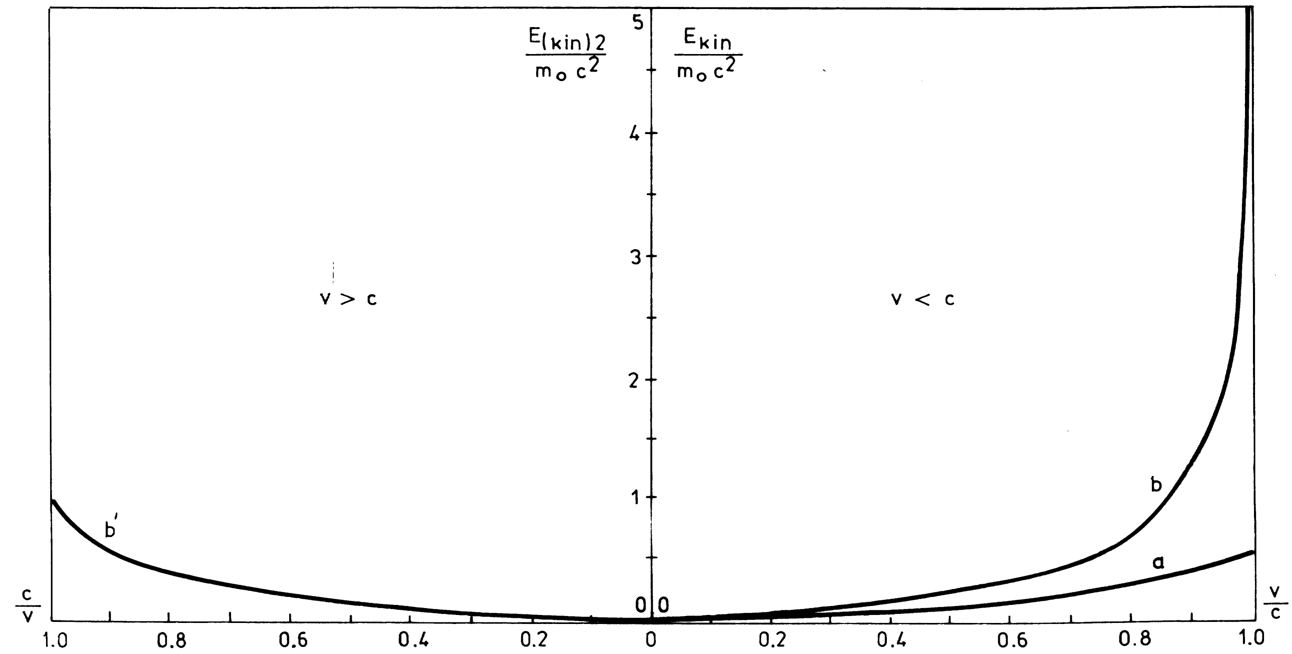


Fig. 6 Variation of kinetic energy and velocity: a) Newtonian, Equation $E_k = \frac{mv^2}{2}$, b) relativistic (special theory), Equation (57) and c) superluminary relativistic, Equation (145).

(which is evident from Fig. 5) then according to Equation (143) the kinetic energy of the particle in the superluminary frame of reference would be,

$$E'_{(kin)2} = m_o\, c^2 \left(1 - \sqrt{1 - \frac{c^2}{v^2}} \right) \tag{145}$$

The magnitudes E'_{kin} and E'_{total} do not correspond completely to the kinetic and total energy, respectively, defined by the valid theory. They have some specific meaning in the system g ' with $v > c$, therefore, they have to be defined according to the SLR theory principles.

The SLR theory definition of E'_{kin} and E'_{total} of the particle in motion with velocity $v > c$, in the system g ' is given after presenting Fig. 6, because the meaning of these two magnitudes then become more explicit.

Fig. 6 plots three curves, which represent the variation of the kinetic energy with velocity:

a) Newtonian, equation,

$$E_k = \frac{mv^2}{2}$$

b) relativistic, Equation (57), and
c) superluminary relativistic, Equation (145).

Having the Equations (145) and (143), for kinetic and total energy, respectively, for system *g* ’, and Fig. 6, now we may define kinetic and total energy by the principles of the SLR theory.

Kinetic energy expressed by the Equation (145) in the system *g* ’, is the energy equivalent to the loss of the mass of the particle in motion with velocity $v > c$. This energy is transformed to the potential energy of the gravitational field and to the emitted particle, as it is to a meson, for instance.

The total energy of the particle in motion with velocity $v > c$ expressed by the Equation (143) is the energy equivalent to the residual mass of the particle with velocity $v > c$ in the system *g* ’.

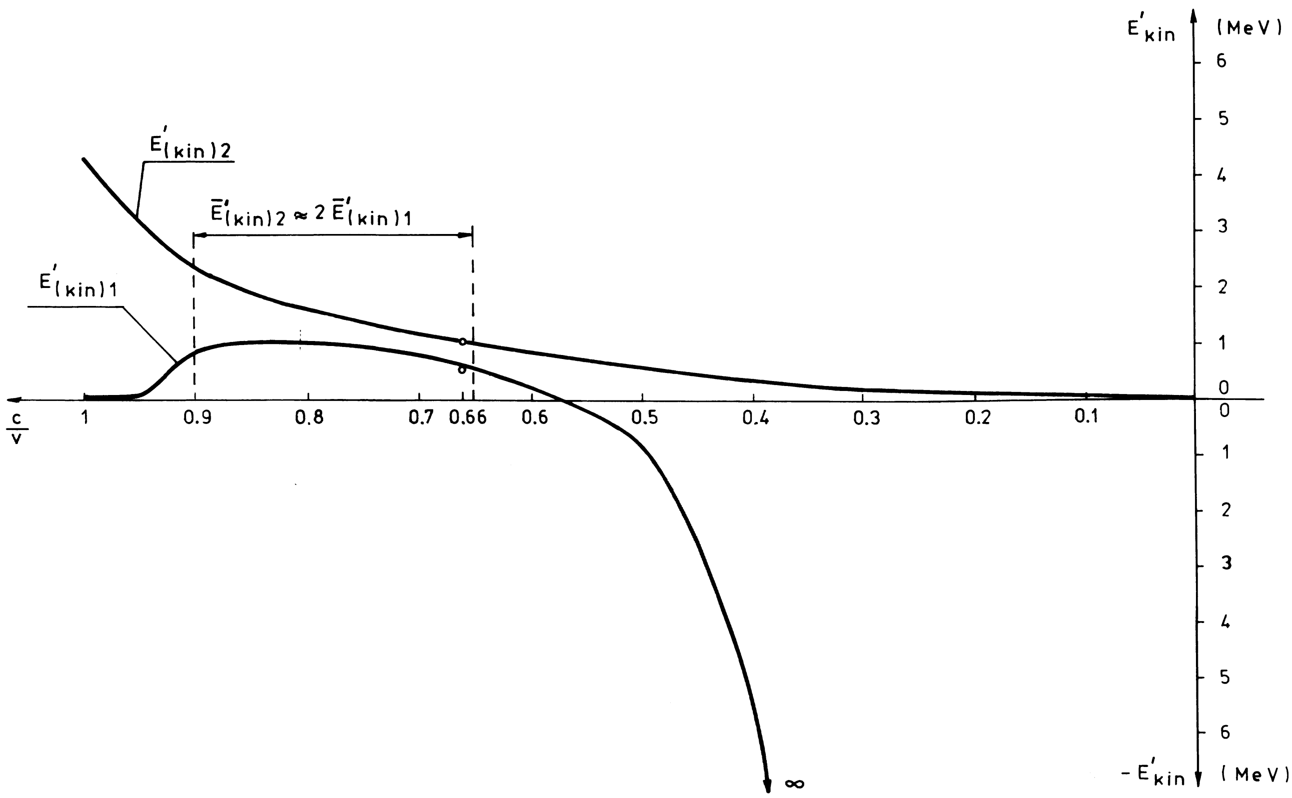
To find the relation between the equations for kinetic and total energy, for the particle in motion, with velocity $v > c$, obtained by two different approaches, those between Equations (132), (133) and Equations (145), (143), it is necessary to compute the kinetic energy for a certain particle for the whole range: from $v = c$ to $v =$ ¥.

T a b l e 1

c/v	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	1
$E'_{(kin)1}$ *(MeV)*	∞	- 2.02	- 43	- 15	- 5.6	- 0.6	0.05	0.72	0.97	0.85	0.11	0
$E'_{(kin)2}$ *(MeV)*	0	$2.2 \cdot 10^{-2}$	$8.7 \cdot 10^{-2}$	0.2	0.36	0.6	0.86	1.23	1.7	2.4	2.95	4.315

$E'_{(kin)1}$ by the Eq. (132); $E'_{(kin)2}$ by the Eq. (145).

Table 1, shows the values of proton kinetic energy in this range of velocities computed by Equations (132) and (145).



<u>Fig. 7</u> Functions $E_{kin}=f\left(\frac{v}{c}\right)$ and $E_{kin}'=f\left(\frac{c}{v}\right)$

Fig. 7 plots two curves, which represent the variation of the kinetic energy, computed by Equations (132) and (145).

For the velocity region from *c/v = 0.7* to *c/v* = 1, negative values for $E'_{(kin)1}$, are obtained using Equation (132) while for the region from *c/v = 0* to *c/v =0.6* positive values are obtained. This is so because Equation (132) corresponds to Equation (133), that is,

$$E'_{(kin)1} = E'_{(total)1} - m_o\, c^2 \tag{146}$$

However, in the system *g* ’, it is,

$$m_o\, c^2 > E_{(total)1} \tag{147}$$

hence, only negative values for $E'_{(kin)1}$ should have been obtained for the whole region of the velocities from $c/v = 0$ to $c/v = 1$, using Equation (132), however, the results obtained are much more complex which is evident from Fig. 7. If we put $-E'_{(kin)1}$ in Equation (146), then we will obtain the equation,

$$E_{(kin)1} = m_o\, c^2 - E_{(total)1} \tag{148}$$

which corresponds to the system g ', and which should be used for the energy equations obtained by both approaches. Therefore, in Table 1, as in Fig. 7 for $E'_{(kin)1}$ opposite signs are used to those obtained by the Equation (132).

As a result of all this, the question about which sets of energy equations are more appropriate should not be considered as settled. Because the set of Equations (143), (144) and (145) give results which are in very good accordance with the experimentally observed magnitudes, these equations have been used in all the further analysis.

Table 1 and Fig. 7 show that in the range of velocities from $c/v = 0.65$ to $c/v = 0.9$ the relation between Equations (145) and (132) is,

$$\overline{E'}_{(kin)2} = 2\,\overline{E'}_{(kin)1} = 2\left[m_o\, c^2 - E'_{(total)1}\right] \tag{149}$$

Out of the latter equation and Equation (145), the equation for the total energy obtained is,

$$E'_{(total)2} = 2\,E'_{(total)1} - m_o\, c^2 \tag{150}$$

and for the rest energy,

$$E'_{02} = E'_{01} = m_o\, c^2 \tag{151}$$

3.5 Consequence of *g* ' = 0: *Intrinsic Vacuum Energy*

Fig. 5 shows two curves, representing both factors g and g '. On the right-hand side of the diagram the function,

$$g = f\left(\frac{v}{c}\right) \tag{152}$$

is presented and on the left-hand side of the diagram the function,

$$g' = f\left(\frac{c}{v}\right) \tag{153}$$

is presented.

The ordinate for both curves is mutual and represents g and g ’, respectively. The abscissa on the right-hand side represents the values of v/c, while the left-hand side represents the values of c/v. For $v = c$, both factors have the same value,

$$g = g' = 1$$

Even at first glance it is obvious that the curves of both functions, plotted in two separate systems, actually form one curve, which in continuity, starting with,

$$g = 0 \tag{154}$$

for the value,

$$v = c \tag{155}$$

is stretching to the end of the other curve, where now for

$$v = c$$

it is,

$$g \to \infty \tag{156}$$

The value,

$$g' = 0 \tag{157}$$

for,

$$v = c$$

in the system, where $v > c$ is possible, is very important, because it may have many consequences in physics. We shall elaborate thoroughly upon the consequences of g ’ = 0 on the main magnitudes of the particles - the mass and the energy.

According to Equation (141) the value of g ’ = 0, implies that the mass of the particle in such a case disappears, the mass is annihilated. Before making an attempt to explain what may happen with energy equivalent to the mass of the particle, in this hypothetical phenomenon, it is necessary to say something about contemporary comprehension of the vacuum.

There are many references with reported theoretical and experimental results, which indicate new properties of the vacuum, and the possibility of the existence of vacuum energy. It is not our intention to make a comprehensive review of such references, however, we need to cite at least two references related to this question. The first one is about vacuum properties [4] and the second is about vacuum energy [14].

In the Summary of the Ref. [14] entitled, ”The Potential of the Vacuum Energy”, it is stated that: ”Loopholes in the Law of Conservation of Energy (if based on an empty vacuum) have been realized by many new energy researches.” We shall elaborate on two important questions, which arise from this sentence.

The first question is: How is the vacuum defined, according to the valid theory and is there an ”empty vacuum”, because it implies a ”not empty vacuum”? In Ref. [15], the next definition for the vacuum is given: ”Fock space contains all the states with an arbitrary number of particles as well as the state in which there is no particle present. This latter state is referred to as *vacuum*.” This definition of a vacuum completely corresponds to the definition of classical physics, but only if a particle is understood as an object with mass. This is so, because according to the kinetic theory of gasses in a confined space, as in a gas container, the pressure is defined by the number of particles pounding on the walls of the container. Photons and particles with no mass cannot produce such an effect, which can be registered by a vacuumeter.

Hence, if there is a massless particle in so confined a space, there is no pressure but it cannot be considered as an ”empty space”. Because the term ”particle” according to contemporary comprehension has a much broader meaning, the same confined space is not ”empty” if there are massless objects of matter, and consequently such a vacuum is not empty. However, even when a confined space is without massless objects and without objects with mass, still this vacuum is not void, because it has certain properties. Ref. [4] we cite here, addresses that problem.

There is another interesting sentence from Ref. [14], referring to this question. It states: ”But we know that the vacuum is not empty by a long shot.”

That the vacuum is not a void and that it has certain properties, is shown by the theoretical and experimental results presented in Ref. [4]. In this reference experimental and theoretical data are presented which show what the vacuum properties are for the distance between particles,

$$r > \frac{h}{m_e c} = l_{ce} \tag{158}$$

where l_{ce} is the Compton wavelength of the electron.

In Ref. [4], Quantum Mass Theory (QMT) is presented, by which, among other things, two new principles are offered: mass conservation principle and mass quantization principle.

The references we have presented here, suggest the necessity to make a distinction between: a vacuum as a space without particles whether they are with mass or massless, and the space which has certain properties even when there are not any kind of objects at all. According to this, a vacuum in any circumstances is not void. The term ”empty vacuum” would imply the possibility that the vacuum is to be considered as a space without any physical properties at all.

The work presented here elaborates on the possibility for the existence of certain vacuum properties of a certain part of space determined by the distances between particles, given as,

$$l_{cp} < r < l_{ce} \tag{159}$$

where l_{cp} is the Compton wavelength of the proton.

The second question from the first sentence of Ref. [14], arises from the statement that new findings about the properties of the vacuum and especially vacuum energy are possible, because of ”Loopholes in the Law of Conservation Energy”. **Our stand point is completely the opposite**: **newly discovered vacuum properties will make it possible to comprehend the hypothetical existance of vacuum energy, but only by preserving the energy conservation law.** It is not justified to expect to have energy balance equation, which will fulfill the energy conservation law, if we do not know all forms of energy participating in certain phenomenon. Consequently, if we do not know the corresponding magnitudes, which represent some of the participants in a certain process, they will not be included in the energy balance equation, and it is quite natural that it will not correspond to the energy conservation law. Thus, if we do not know the magnitude, which represents the vacuum energy in the newly observed experiments, we cannot use the energy balance equation. Therefore, it is not justified to claim that energy conservation law is not valid, in the newly observed experiments.

These, our statements, we shall try to prove when the newly formulated equations for energy in the system g ’, obtained by the analysis presented, are applied to certain examples.

Before we do that, we still feel the necessity to explain our standpoint about the conservation laws described above.

If the new model for the molecule, atom or even nucleus, is accepted, it is still not new physics. However, if some of the fundamental laws of physics are canceled, like conservation laws, then it would be entirely new physics. Therefore, the theory and analysis presented here is an attempt for the concepts of Special and General Relativity to be extended into the superluminary frame of reference by preserving the conservation laws.

Now, we may return to the result of the analysis, that in system *g '*, for $v = c$ the mass of the particle vanishes, i.e.,

$$m = 0 \tag{160}$$

Keeping in mind that energy conservation law should be preserved, it seems that there are four possible alternatives of what could happen to the energy of the vanishing mass of the particle. The essential assumption is that energy equivalent to the vanishing mass of the particle, should transfer into other forms of energy. Here are those four alternatives:

1. The disappearance of the mass of the particle may result in photon emission, hence,

$$E'_{total} = mc^2 = \sum hn \tag{161}$$

   The total energy of the particle will be equal to the sum of the energies of all kinds of emitted photons.

2. Transmutation of the particle with mass *m* into masless particles, such as neutrino and antineutrino, will be presented by the next expression,

$$E'_{total} = mc^2 = E_n + E_{\bar{n}} \tag{162}$$

   Where, E_n is the energy of all emitted neutrinos and $E_{\bar{n}}$ is the energy of all emitted antineutrinos.

3. If the mass, which disappears, is from the charged particle, the charge will be preserved. None of the derived equations in the analysis include the charge, consequently, the charge conservation law is preserved as well. Therefore, the possibility of transmutation of the particle with mass and charge into a massless charged particle should be assumed. † Hence,

$$E'_{total} = mc^2 = E_e \tag{163}$$

   where E_e, stands for the energy of the massless particle with a charge.

† The possibility of the existance of the particle with a charge but without gravitational mass, was predicted by Einstein in 1936. See Ref. [13] and [16].

4. Because there are many reported experimental and theoretical results about new vacuum properties and especially about the possibility of the existance of vacuum energy, there are two additional possibilities of what might happen with the energy of the vanishing mass of the particle:

Firstly: If the vacuum is defined as a part of space where no particles with mass are present, but where there may be present all other massless objects from the microworld, including all kinds of physical fields, then such a space will contain the energy of all the massless objects plus the energy of the physical fields. So the comprehended vacuum, will have a vacuum energy expressed by the equation,

$$E'_{total} = mc^2 = E_n + E_h \tag{164}$$

where,

E_n - is the energy of massless objects, and
E_h - is the energy of physical fields.

Secondly: If the vacuum is comprehended as a space without any kind of particles, with or without mass, and where there are no kind of physical fields present, still it has its own physical properties, and consequently its intrinsic vacuum energy. Thus, we may assume two possibilities:

a) part of the total energy of the vanished mass to be transferred to the massless particles and physical fields, and part of it into magnitude which we would call,

***intrinsic vacuum energy*.**

This case may be expressed as

$$E'_{total} = mc^2 = E_n + E_h + E_{vi} \tag{165}$$

where E_{ni} stands for *intrinsic vacuum energy*;

b) the possibility of the total energy of the particle being transferred to the *intrinsic vacuum energy*, i.e.,

$$E'_{total} = mc^2 = E_{vi} \tag{166}$$

The last item suggests the possibilities of the reverse phenomenon: the vacuum energy being transferred to other forms of energy.

4. EXAMPLES OF PARTICLE REACTIONS

We shall try to apply the theory presented and the equations obtained by the analysis, to the imaginary phenomena, which are very close to the real ones, because it will be based on real reactions. We shall use two fundamental reactions that underlie the nuclear structure, in which the weak interactions of nucleon and lepton fields are presented.

The first reaction is absorbtion of m – neutrino by neutron, with the result of the emission of a muon and a proton [15]:

$$n + n_m \to p + m^- \tag{167}$$

The second reaction is the reverse of the first one, i.e., when the proton captures the muon and the result is neutron and m – neutrino [15]:

$$p + m^- \to n + n_m \tag{168}$$

Where, in both expressions,

n - is neutron,
n_m - is m – neutrino,
p - is proton and
m^- - is muon.

The muon decay is,

$$m^- \to e^- + n_m + \overline{n_e} \tag{169}$$

Where,

e^- - is electron, and,
$\overline{n_e}$ - is electron antineutrino.

The muon mean life is

$$T = 2.6 \cdot 10^{-6} \text{ sec}. \tag{170}$$

4.1 **Reaction No. 1: Neutron absorbtion of *m*-neutrino**

Neutron absorbtion of $m-$ neutrino results in neutron decay into a proton and a muon [15],

$$n + n_m \to p + m^- \tag{171}$$

The energy of $m-$ neutrino is [15],

$$E_n < 1.6\ MeV \tag{172}$$

thus, in this case we shall take,

$$E_n = 1.5\ MeV \tag{173}$$

The energy of the neutron, which has absorbed $m-$ neutrino is,

$$E_{nn} = E_n + E_n = 941.05\ MeV \tag{174}$$

The mass of this neutron will be,

$$m_n' = 1.6744 \cdot 10^{-27}\ kg \tag{175}$$

The mass of $m-$ neutrino is,

$$m_n = 2.67 \cdot 10^{-30}\ kg \tag{176}$$

The muon has an energy of [15],

$$E_m = 105.6599\ MeV \tag{177}$$

and its mass is,

$$m_m = 1.8807 \cdot 10^{-28}\ kg \tag{178}$$

We shall consider the phenomenon in which, because of the action of nuclear forces the neutron and proton will rotate. The neutron will rotate in one circle, and the proton will rotate in another circle with another radius.

Let us assume that the neutron will rotate in a circle with a radius,

$$r_n < \frac{1}{2} l_{ce} \tag{179}$$

where l_{ce} is the Compton wavelength of the electron. Thus we shall take,

$$r_n = 1.3 \cdot 10^{-13}\ m \tag{180}$$

The tangential velocity of the neutron will be

$$v_n = 1.4 \cdot 10^{7}\ m/s \tag{181}$$

and its kinetic energy then is,

$$E_{kn} = m'_n c^2 \left(\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 1 \right) \tag{182}$$

where,

$$m'_n = m_n + m_n \tag{183}$$

thus,

$$E_{kn} = 1.0223\ MeV \tag{184}$$

According to Equation (171) this neutron will decay into a proton and a muon.

Let us assume, that nuclear forces will make the proton and the muon rotate in a circle with same radius, i.e.,

$$r_p = r_m > \frac{1}{2} l_{cp} \tag{185}$$

where,

$$l_{cp} = 1.3214 \cdot 10^{-15}\ m \tag{186}$$

is the Compton wavelength of the proton.

We shall take,

$$r_p = r_m = 2 \cdot 10^{-15}\ m \tag{187}$$

The tangential velocity of the proton is,

$$v_p = 5.45 \cdot 10^{8}\ m/s \tag{188}$$

and tangential velocity of the muon is,

$$v_m = 3.13 \cdot 10^8 \ m/s \tag{189}$$

It is obvious that,

$$v_p > c \tag{190}$$

and also,

$$v_m > c \tag{191}$$

Therefore for this phenomenon we shall apply relativistic Equation (145) to the kinetic energies of the proton and muon, because they are in the system *g* ’. However, to determine kinetic energy in the system *g* it is necessary to introduce the constant M_c into Equation (145). As the following analysis will show, this constant will connect energy magnitudes of the system *g* with those of system *g* ’. Thus, Equation (145) for the system *g* becomes,

$$E_{kin} = M_c \, E'_{kin} \tag{192}$$

or,

$$E_{kin} = m_o \, c^2 \, M_c \left(1 - \sqrt{1 - \frac{c^2}{v^2}} \right) \tag{193}$$

Hence, the kinetic energy of the proton is,

$$E_{kp} = m_{po} c^2 \, M_c \left(1 - \sqrt{1 - \frac{c^2}{v^2}} \right) \tag{194}$$

which yields,

$$E_{kp} = M_c \, 155.157 \ MeV \tag{195}$$

The kinetic energy of the muon is,

$$E_{km} = m_m \, c^2 \, M_c \left(1 - \sqrt{1 - \frac{c^2}{v^2}} \right) \tag{196}$$

which yields,

$$E_{km} = M_c \, 76.17 \ MeV \tag{197}$$

The sum of the proton and muon kinetic energy gives,

$$E_{kpm} = E_{kp} + E_{km} = M_c \; 231.327 \; MeV \tag{198}$$

According to Equation (192) it is obvious that,

$$E_{kpm} = E'_{kpm} \; M_c \tag{199}$$

The gain of the kinetic energy in the described reaction with the phenomenon of rotation of the particles, is a result of the action of the nuclear forces, which make these particles rotate.

Our initial standpoint was, that conservation laws should be preserved. By using momentum conservation law, the tangential velocities of the particles in the second circle with radius r_p are determined. The same procedure will be conducted in the next reaction, therefore we may conclude that momentum conservation law is already included. However, our main task is to show that energy conservation law is valid for both systems, *g* and *g* ', and that magnitudes which are in these two systems can be connected by a certain constant.

The supposition that,

$$E_{kn} = E_{kpm} \tag{200}$$

yields,

$$\frac{E_{kn}}{E'_{kpm}} = M_c \tag{201}$$

where,

$$M_c = 8.11 \frac{l_{cp}}{l_{ce}} = 4.42 \cdot 10^{-3} \tag{202}$$

Then Equation (199) becomes,

$$E_{kpm} = 8.11 \frac{l_{cp}}{l_{ce}} E'_{kpm} = 4.42 \cdot 10^{-3} \; E'_{kpm} \tag{203}$$

which yields,

$$E_{kpm} = 1.0217 \; MeV \tag{204}$$

and we may consider that the supposition expressed by Equation (200)

$$E_{kn} = E_{kpm} \tag{205}$$

is justified.

The last equation shows that by taking into account the constant M_c, energy conservation law is preserved. Equation (202) shows that the constant M_c is determined by two magnitudes l_{cp} and l_{ce}, which actually determine the space where the imagined phenomenon is taking place. This constant does not depend on the structure of the nucleus or on the nuclear forces. It depends only on the magnitudes which determine the part of the space where the given reaction and rotation of the particles is taking place.

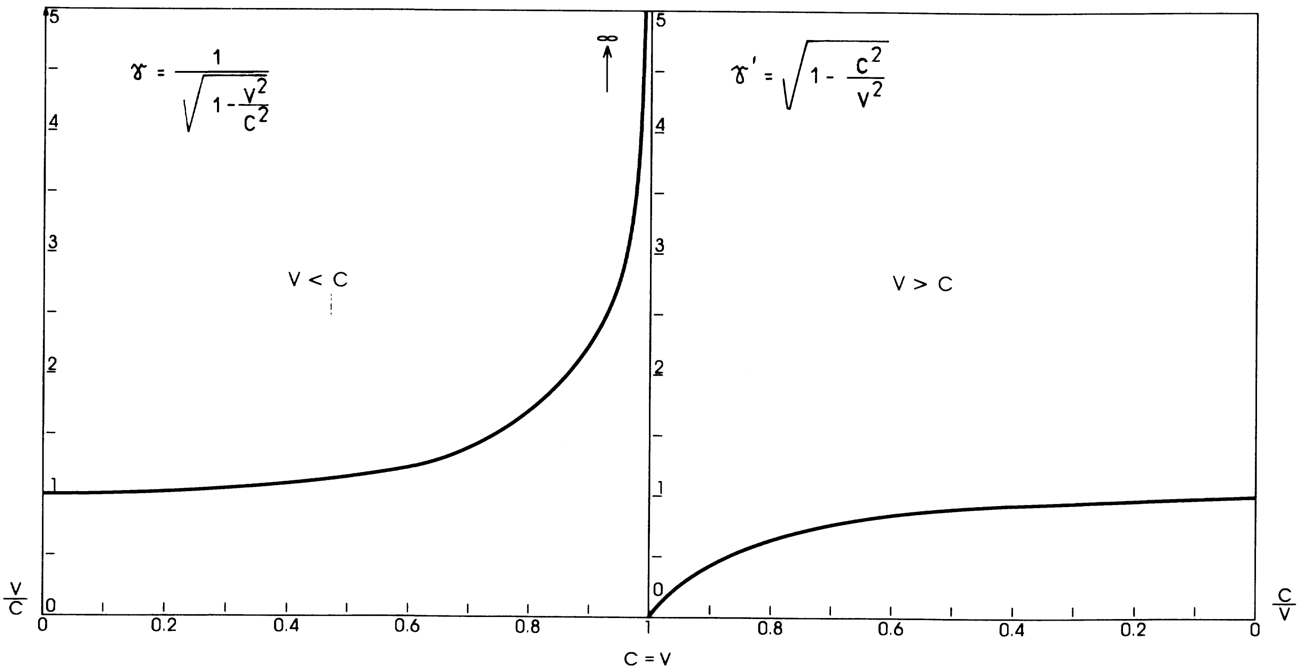


Fig. 8 Functions $g = f\left(\frac{v}{c}\right)$ and $g' = f\left(\frac{c}{v}\right)$ with common point $c = v$.

There is an important question which arises from the results of this analysis. The question arises from the diagram of Fig. 5, if it is arranged as it is presented in Fig. 8. The question is: how the particle with $v < c$ in the system g can overcome the barrier $v = c$, and achieve the velocity $v > c$, in the system g '?

In our analysis we have seen that, the neutron at the beginning of the reaction has velocity,

$$v_n < c \tag{206}$$

while the particles emerging from the reaction, the proton and muon have the velocities,

$$v_p > c \tag{207}$$

and

$$v_m > c \tag{208}$$

In Fig. 5, the curve of the function,

$$g = f\left(\frac{v}{c}\right) \tag{209}$$

shows that for $c = v$, $g \to 8$, while the curve of the function,

$$g' = f\left(\frac{c}{v}\right) \tag{210}$$

for $v = c$, gives,

$$g' = 0 \tag{211}$$

The question was, how certain particles, can overcome the barrier $v = c$ in their transition from the system g , into the system g ’? For one particle to overcome the barrier $v = c$, means, the mass of the particle first has to reach the value $m \to 8$ in the system g , which is impossible, and even if that happened, it should drop instantly to the value $m = 0$. If there is any phenomenon in nature which is at least close to this one, it would be necessary to find out what the properties of both systems are, in the sections where they are interconnecting, in order to explain it.

The phenomena we are considering, do not include such a situation, i.e., the particles of the system g are not the same as the particles of system g ’. This means, there is no such particle which has to overcome the barrier $v = c$.

In the system g , before the reaction takes place, there is a neutron with $v < c$. As a result of the reaction two new particles emerge and they are in the system g ’ with velocities $v > c$. This suggests the possibility that residual particles gain velocities $v > c$, if they find themselves in the system g ’. The system g ’ is determined by certain dimensions of the space by the magnitudes l_{cp} and l_{ce}, and these particles will be brought to the system g ’ by the nuclear forces. All this also suggests that, this part of the space has the sort of properties which allow such kinds of transmutations and transitions.

It is worthwhile mentioning another phenomena here. A photon emitted from electron transition in the atom has a velocity *c*, the velocity of light in vacuum, which is not comparable with the velocity of the electron performing such an transition.

Now, can we specify the circumstances in which such vacuum properties can be expressed? These circumstances are expressed by the constant M_c which is defined either as,

$$M_c = 8.11 \frac{l_{cp}}{l_{ce}}$$

or, as,

$$M_c = 8.11 \frac{m_e}{m_p} \tag{212}$$

In the first version with l_{cp} and l_{ce}, M_c determines a certain section of the space. However, the second version when M_c is expressed by the ratio of the electron and proton masses, the same part of the space is determined by certain properties of the mass. In other words, the part of the space where the system *g* ’ is determined by M_c, has the properties defined by certain electron and proton properties, that is, by their masses. By this we have come up to a very important conclusion: **besides the electromagnetic properties m_o and e_o vacuum has certain properties which are connected to the mass properties of the particles**.

The properties of the space designated as system *g* ’ where $v > c$ is possible, are more explicitly represented by the constant with dimensions, i.e.,

$$M_c' = M_c c^2 \tag{213}$$

$$M_c' = 8.11 \frac{m_e}{m_p} c^2 \tag{214}$$

$$M_c' = 3.978 \cdot 10^{14} \, (m/s)^2 \tag{215}$$

By this constant the properties of the space designated by the system *g* ’ are expressed by a magnitude with dimension $(m/s)^2$. The velocity of light in the system *g* ’ can be determined from this constant. Thus, the velocity of the light in system *g* ’ where $v > c$ is possible, is

$$c' = \sqrt{M_c'} = 1.9945 \cdot 10^7 \ m/s \tag{216}$$

The value obtained shows that,

$$c' < c$$

The conclusion would be: in the system *g* ', which is part of the space where *v* > *c* is possible, represents the vacuum with properties connected with masses of the particles. Thus, these properties in the system *g* ', prevail, over the electromagnetic properties of the vacuum. Therefore, the velocity of light in the system *g* ' is decreased compared to its velocity in the system *g* , where there are dominant electromagnetic properties of the vacuum. Such a part of the space, where properties prevail of the mass rather than the electromagnetic properties, is the space occupied by nucleons, which constitute the structure of the nucleus.

According to the principles of General Relativity [3], the velocity of light is not constant, even in vacuum. The velocity of light depends on the distribution of the masses and on the distances between the bodies which produce gravitational fields [3].

According to the General Relativity for the propagation of light in vacuum, at distance *r* from the body with mass *m*, the velocity of light is [3],

$$c' \approx c\left(1 - \frac{2Gm}{c^2 r}\right) \tag{217}$$

where,

G - is the gravitational constant,
r - is the distance from the center of the body with mass *m*, and the point where the light velocity is observed.

The last expression gives only the first approximation of the change of the light in the circumstances described, but it is obvious that,

$$c' < c \tag{218}$$

something that we have obtained by the constant M'_c. This constant determines the velocity of light in the space defined by the masses of two particles, the proton and neutron.

Equation (216) derived by the theory presented, determines the velocity of light in the space occupied by the mass of the nucleus, and Einstein's Equation (217), determines the velocity of light as dependent on the gravitational mass and the distance from that mass. Both equations show, that

$$c' < c$$

This, actually shows that General Relativity can be applied to the nuclear processes if the principles of the theory presented are applied. This notion should be thoroughly elaborated on because it leads to the conclusion of the possibility, that the concepts of Special and General Relativity can be connected by the theory of Superluminary Relativity and Quantum Mass Theory and applied to the nuclear structures and processes.

The conclusion for this subsection will be: the increase of the kinetic energy of residual particles of the reactions is a result of the action of nuclear forces, but that is possible because of the existance of certain vacuum properties defined by the constants,

$$M_c = 8.11 \frac{m_e}{m_p}$$

and,

$$M_c' = M_c c^2$$

To verify the validity of the equations obtained for the system *g* ’ where $v > c$ is possible, and consequently the validity of constants M_c and M_c', we shall analyse another reaction by using those equations and constants.

4.2 <u>Reaction No. 2: Muon capture by proton</u>

It would be convenient if we considered the reaction, which is the reversal of the first one, i.e.,

$$p + m^- \rightarrow n + n_m \qquad (219)$$

In this reaction the proton captures the muon and then the proton decays into a neutron and m – neutrino.

The proton and muon will be in the same orbit as in the first reaction, i.e., they will rotate in a circle with radius,

$$r_p = r_m < \frac{1}{2} l_{ce} \qquad (220)$$

that is,

$$r_p = r_m = 1.3 \cdot 10^{-13}\ m \qquad (221)$$

Their velocities will be the same,

$$v_p = v_m = 1.4 \cdot 10^7 \ m/s \tag{222}$$

Hence, the kinetic energy of the proton is,

$$E_{kp} = m_{po} c^2 \left(\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 1 \right) \tag{223}$$

which yields,

$$E_{kp} = 1.0212 \ MeV \tag{224}$$

The kinetic energy of the muon is,

$$E_{km} = m_m c^2 \left(\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 1 \right) \tag{225}$$

which yields,

$$E_{km} = 0.11235 \ MeV \tag{226}$$

The sum of the proton and muon kinetic energies gives,

$$E_{kpm} = E_{kp} + E_{km} = 1.1335 \ MeV \tag{227}$$

According to expression (219), the result of the proton-muon interaction is a neutron and $m-$neutrino. The neutron will rotate in the same second orbit as in the first reaction, with radius,

$$r_n < \frac{1}{2} l_{cp} \tag{228}$$

that is,

$$r_n = 2 \cdot 10^{-15} \ m \tag{229}$$

with velocity,

$$v_n = 4.5335 \cdot 10^8 \ m/s \tag{230}$$

It is obvious that $v > c$, therefore we have to apply Equation (193) here for kinetic energy, i.e.,

$$E_{kn} = m_{no} \, c^2 \left(1 - \sqrt{1 - \frac{c^2}{v^2}} \right) M_c \tag{231}$$

which yields,

$$E_{kn} = 1.038 \, MeV \tag{232}$$

If we compare the latter value with E_{kpm} to the first part of the reaction, the difference is 9.2%. The accuracy of 9.2% is not good. But constant,

$$M_c = 4.42 \cdot 10^{-3}$$

is determined only by using one reaction. The corrected value,

$$M_c = 4.6 \cdot 10^{-3} \tag{233}$$

which covers both considered reactions here, gives the accuracy of 4.8%, which can be considered as acceptable.

The necessary time for the proton and neutron to complete one circle with radius,

$$r = 1.3 \cdot 10^{-13} \ m \tag{234}$$

is,

$$T = 5.83 \cdot 10^{-20} \ s \tag{235}$$

Because this time is too short, when the neutron is in this orbit, it will not decay before the described reactions are completed.

5. REAL AND VIRTUAL MAGNITUDES

Two sets of energy Equations (133), (134), (132) and (143), (144), (145) give the real total energy, real rest energy and real kinetic energy, respectively, for the particle in the frame of reference S'.

For the observer O' in the frame of reference S', these magnitudes are real, however for the observer O in the frame of reference S, these magnitudes are virtual.

To satisfy the first principle of Superluminary Relativity, the energy conservation law has to be preserved. Therefore, the constant M_c has to be introduced which will connect energy magnitudes from both frames of reference, that is, *g '* and *g* .

In both examples of particle interactions, the computations have shown that,

$$E_{kin} = M_c \, E'_{kin} \tag{236}$$

for the first approach for determining the energy magnitudes when they have subscript 1, the latter equation yields,

$$E_{kin} = M_c \, m_o \, c^2 \left\{ \frac{1}{2}\sqrt{1-\frac{c^2}{v^2}} - \ln\left[v\left(1+\sqrt{1-\frac{c^2}{v^2}}\right)\right] + \ln c \right\} \tag{237}$$

Knowing that in the system S the kinetic energy is given by the equation,

$$E_{kin} = E_{total} - m_o \, c^2 \tag{238}$$

and by substituting this equation and Equation (148) into Equation (236), the equation which connects the total energies in the systems S and S' is obtained, that is,

$$E_{total} - m_o \, c^2 = M_c \left(m_o \, c^2 - E_{(total)1} \right) \tag{239}$$

or,

$$E_{total} = m_o \, c^2 \left(M_c + 1 \right) - M_c \, E'_{(total)1} \tag{240}$$

The rest energies are connected by the equation,

$$E_o = E'_{o1} \tag{241}$$

or,

$$E_o = m_o \, c^2 \tag{242}$$

When Equations (236) and (238) are applied to the second approach for determining the energy magnitudes designated by subscript 2, the following correlation between the energy magnitudes in the systems S and S' are obtained.

The total energies in system S and system S' are connected by the equation,

$$E_{total} = m_o \, c^2 \left(M_c + 1 \right) - M_c \, E'_{(total)2} \tag{243}$$

For the rest energies the expression is obtained,

$$E_o = E'_{o2} \tag{244}$$

or,

$$E_o = m_o c^2 \tag{245}$$

and the kinetic energies are given by the equation,

$$E_{kin} = M_c E'_{(kin)2} \tag{246}$$

or,

$$E_{kin} = M_c m_o c^2 \left(1 - \sqrt{1 - \frac{c^2}{v^2}}\right) \tag{247}$$

The magnitudes expressed by Equations (133), (134), (132) and Equations (143), (144), (145) are real for the g '-system, where $v > c$ is possible, and where the principles of Superluminary Relativity and principles of Quantum Mass Theory are valid. These magnitudes are virtual for the g -system, where $v < c$ is possible, and concepts of Special Relativity are valid. These magnitudes become real for the g -system when the constant M_c is applied, and energy conservation law can be preserved.

The constant M_c plays a very important role in this theory, because in the equation of the system for $v > c$, it establishes the correlation between the magnitudes of the both systems, g ' and g . From the analysis, the definition of this magnitude and its value, are found.

It has been found that,

$$M_c = 8.44 \frac{l_{cp}}{l_{ce}} = 4.6 \cdot 10^{-3} \tag{248}$$

where,

$$l_{cp} = \frac{h}{m_p c} = 1.3214 \cdot 10^{-15}\, m \tag{249}$$

is the Compton wavelength of the proton and

$$l_{ce} = \frac{h}{m_e c} = 2.4262 \cdot 10^{-13}\, m \tag{250}$$

is the Compton wavelength of the electron, where h is Planck’s constant.

Thus, the constant M_c can now be expressed by the equation,

$$M_c = 8.44 \frac{m_e}{m_p} = 4.6 \cdot 10^{-3} \tag{251}$$

where,

m_p – is the rest mass of the proton and
m_e – is the rest mass of the electron.

From Equation (248), the M_c determines a certain range of the space, between two limits, l_{cp} and l_{ce}, while from Equation (251) the same space is characterised by the ratio of the proton and electron rest masses.

If we connect the constant M_c with the velocity of light, then a new important constant emerges,

$$M_c' = M_c c^2 = 3.978 \cdot 10^{14} \left(m/s\right)^2 \tag{252}$$

This constant with a dimension of $\left(m/s\right)^2$ determines the vacuum properties in the system where

$$v > c. \tag{253}$$

is possible.

The constant M_c' connects the two systems *g* and *g '*, and by that shows that these two systems are not two separate worlds with two different physics. First of all, it shows that in both systems physical laws are valid, for instance, energy conservation law, and secondly, it also shows that in the same space either system *g* or system *g '* may exist, depending only on, which vacuum properties prevail in a certain situation.

This explains the nature of the factor *g '* and the constant M_c. **The factor *g '* determines the real value of the magnitude in the system *g '*, while the constant M_c is the connection between the magnitudes of the two systems *g '* and *g* .**

In Section III the gravitational field and its energy as well as the gravitational force between the masses in the nuclear structures is thoroughly elaborated, by using SLR theory principles. It is important to emphasise that all gravitational magnitudes defined by SLR theory obey the Newtonian law of gravitation and, the only difference is the gravitational constant derived by SLR theory principles for masses and distances characteristic for nuclear structures.

Here we will use the equation for gravitational field energy in the proton-neutron system in order to find the correlation between the gravitational magnitudes of both systems, g and g ', in other words S and S'.

The stable proton-neutron system creates a deuteron nucleus. This is a much more complex system than a proton-neutron system, because of the presence of two binding mesons, emitted and absorbed by the proton and neutron. This will be elaborated on in detail in Section III. Here, we will assume the existence of the proton-neutron system in order to determine the correlation of real and virtual magnitudes which express the gravitational effects.

In the system g, that is system S, the gravitation field energy, between the particles which constitute the nucleus, is defined by Quantum Mass Theory [4], and is given by the equation, for deuteron nucleus (see Sec. III),

$$E_m = G'_d \frac{m_p\, m_n}{r} \tag{254}$$

where,

$$G'_d = 4.6 \cdot 10^{26}\ N m^2\, kg^{-2} \tag{255}$$

is the gravitational constant for masses and distances characteristic for nuclear structures.

According to Assumption 4, it is,

$$F_{repulsion} = -F_{attraction} \tag{256}$$

which means,

$$E_{kin} = E_m \tag{257}$$

In the system g ', that is system S', the energy of the gravitational field between the proton and the neutron, which are in motion with velocities $v > c$, is given by the equation,

$$E'_m = G'(g')\frac{m_p\, m_n}{r} \tag{258}$$

where,

G'(g ') - is the gravitational constant for masses and distances characteristic for nuclear structures, in the system g '.

In the system g ' also,

$$F'_{repulsion} = -F'_{attraction} \tag{259}$$

that is,

$$E'_{kin} = E'_m \tag{260}$$

Because, we have already established that,

$$E_{kin} = M_c \, E'_{kin} \tag{261}$$

it follows that,

$$E_m = M_c \, E'_m \tag{262}$$

Hence,

$$E'_m = \frac{1}{M_c} E_m \tag{263}$$

that is,

$$E'_m = \frac{1}{M_c} G'_d \, \frac{m_p \, m_n}{r} \tag{264}$$

where,

$$G'(g\,') = \frac{1}{M_c} G'_d = 10^{29} \; N \, m^2 \, kg^{-2} \tag{265}$$

and,

$$E'_m = 10^{29} \; N \, m^2 \, kg^{-2} \tag{266}$$

and finally,

$$E'_{kin} = E'_m = 10^{29} \, \frac{m_p \, m_n}{r} \tag{267}$$

Because the magnitude E'_{kin} is defined as the energy equivalent to the mass lost by the particle in motion with velocity $v > c$, Equation (267) shows that the magnitude E'_{kin} represents the energy transformed from the particle in motion with velocity $v > c$, to the gravitational field energy E_m . In fact, in Section III, it will be shown that E'_{kin} represents the sum of the energies transformed into the gravitational field between all of the participating particles in the considered system, and the energy of the emitted and absorbed mesons by the proton and neutron, in the deuteron nucleus.

The Equations (254), (258) and (266), actually represent gravitational magnitudes which obey Newton's law of gravitation, but for nuclear structures, that is for systems with masses and distances characteristic for nuclei. The constants G'_d and $G'(g\,')$ are modified gravitational constants for such systems.

6. CONCLUSIONS

How much the imagined phenomena for which the presented analysis is developed are close to real nuclear phenomena, will be shown again by comparison of imagined phenomena with nuclear structure of a concrete nucleus.

We have considered two reactions: in the first one, the residual main particle is a proton and in the second, the main residual particle is a neutron. These reactions have been considered separately. If we suppose that these particles, both proton and neutron, are rotating at the same time, in the same orbit with the same radius, which has been used in the computation, that is

$$r_p = r_n = 2 \cdot 10^{-15}\ m$$

we may suppose that at a certain moment they will reach a distance from each other,

$$d = 4 \cdot 10^{-15}\ m$$

The system made of these two particles, proton and neutron in the described circumstances, will be with total kinetic energy, obtained as a sum of kinetic energies of both particles, i.e.,

$$\sum E_k = E_{kp} + E_{kn} = 2.26\, MeV$$

If we compare these two magnitudes of this imagined proton-neutron system, with corresponding magnitudes for the deuteron nucleus, we shall come to certain conclusions.

In the deuteron nucleus, the distance between the proton and the neutron is,

$$D_d = 4 \cdot 10^{-15}\ m$$

which is exactly the same distance between the proton and neutron in the imagined system.

The binding energy of the deuteron nucleus is,

$$E_{bd} = 2.22\ MeV$$

Comparison of the binding energy of the deuteron nucleus with the kinetic energy of the imagined proton-neutron system shows a difference of 1.6%.

Our next task is to consider a real proton-neutron system, and to see if there is any possibility of comparing the p - n system with the deuteron nucleus by using the concepts of Superluminary Relativity and Quantum Mass Theory.

III. NUCLEAR FORCES EXPLAINED BY SUPERLUMINARY RELATIVITY AND BY QUANTUM MASS THEORY

1. INTRODUCTION

In this section an attempt to apply Quantum Mass Theory [4] to the nuclear processes is presented, starting with an analysis by which a new approach for the explanation of nuclear forces is offered.

In the previous section we have considered imagined phenomena in order to analyze the proton-neutron system and to formulate equations for a region of the space where $v > c$ would be possible. In the analysis of the imagined phenomena with protons and neutrons the forces, which have put involved particles in the corresponding positions have been ignored. Now, we will try to offer acceptable explanations for the physical processes, which bring the participating particles into certain positions in the space and cause them to have certain energies. For that purpose we shall make a comparison of the proton-neutron with the deuteron nucleus.

Our main task is to provide sufficiently convincing proofs for our theory for Superluminary Relativity. Since we decided, at the beginning of the analysis in Section II, to investigate these possibilities in the microworld, or more precisely, in the world of nuclei, we have to include in the analysis the processes connected with nuclear forces.

We shall start here with the fact that, in current theories which explain nuclear processes, and consequently nuclear forces, two main laws in physics are violated [15], [17]:

- energy conservation law, and
- angular momentum conservation law.

The second inspirational motive for this work is the next additional reason. In current theories it is admitted that: ”Our understanding of nuclear forces is still rather limited” [15].

For all the reasons listed above, by using principles of Quantum Mass Theory we shall try thoroughly to elaborate on the proton-neutron system and the deuteron nucleus. We make a distinction between the proton-neutron system in an unstable state, which does not constitute the deuteron nucleus, and the proton-neutron system in a stable state, which creates the deuteron nucleus.

2. NUCLEAR FORCES

The nucleons bond themselves to each other in the nucleus as a result of force that acts between nucleons. The two forces already known in physics, gravitational and electromagnetic, according to current theories are too weak to produce this binding. Since in the nucleons there are positively charged particles, protons, and neutral particles, neutrons, the electromagnetic force in the nuclei appears to be a repulsive force, which makes the total results of these two forces between the nucleons even weaker.

To explain contemporary understanding of nuclear forces we shall borrow citations from the references [15], [17] and [18] in short and modified forms.

According to current theories nuclear forces can be described in the next eight items [15]:

a) Inside the nucleus the nuclear force is substantially stronger than the electromagnetic interaction, or otherwise most stable nuclei would not exist.

b) The nuclear force is attractive, or at least has dominant attractive components in it. This again follows from the fact the nuclei are bound.

c) The nuclear force has a short range, shorter than the interatomic distances. The range of nuclear forces is of the order of magnitude of the radius of the nucleus that equals approximately the average distance between nucleons in the nucleus, that is, between 1 and 2 fermis.

d) Nuclear forces have a saturation property; in other words their general character is such that each one of them cannot interact with more than the few nucleons within its range of influence.

e) The strength of a force cannot be measured just by binding the energy it produces. There is another energy to which it should be compared. Consider a two-nucleon system, that is, the deuteron nucleus. If we force the nucleons to be within the range of their mutual (nuclear) interaction, we increase their relative momentum because of the uncertainty relation,

$$\Delta p \, \Delta x \approx \hbar \tag{268}$$

That leads to an increase in their kinetic energy in the centre-of-mass system,

$$E_{kin} = \frac{(\Delta p)^2}{2(m/2)} \approx \frac{\hbar}{m(\Delta x)^2} \tag{269}$$

The reduced mass *m/2* is used in the latter equation to emphasize that we are dealing with the relative kinetic energy. The nuclear attraction has to overcome this kinetic energy in order to produce a bound state, so it is therefore natural to ask whether its binding energy is large or small compared to E_{kin} in the latter equation.

From the fact that there is only one bound state known for the two-nucleon system - the deuteron - we consider that the nuclear interaction is barely strong enough to overcome the kinetic energy that results when the two nucleons come within each other's range. Thus, the nuclear interaction is basically a *weak* interaction - which is weak by comparison to its task of overcoming E_{kin} in Equation (269).

f) The nuclear force depends not only on the relative separation of the two nucleons, but also on their intrinsic degrees of freedom - the spin and the charge. Its dependence on the spins of the interacting nucleons can be inferred from the fact that the only bound *p* - *n* system - the deuteron - has the proton and neutron spins parallel to each other giving rise to a total angular momentum $J = 1$.

The evidence for the various components in the nucleon-nucleon interaction comes from many sources, the most direct one being nucleon-nucleon scattering experiments.

One of the important magnitudes of the deuteron nucleus is the distance between nucleons [15], [17], [18],

$$r_d = 4 \cdot 10^{-15} \ m \tag{270}$$

The second important magnitude of the deuteron nucleus is its binding energy [15], [17], [18],

$$E_{bd} = 2.22 \ MeV \tag{271}$$

The third important deuteron nucleus magnitude is its magnetic moment [15], [17], [18],

$$m_D = 0.85742\ nm \tag{272}$$

g) An interaction between two nucleons, like every other interaction involves an exchange of momentum between them. It has been found, however, that the two nucleons can also exchange their charges at the same time. This is manifested most dramatically in p - n scattering experiments that show a peaking of differential cross sections at backward angles (in the centre-of-mass system).

h) Nucleon-nucleon scattering at high energies - 200 MeV laboratory energy and more - shows that at very small separations the nucleon-nucleon interaction becomes very strongly *repulsive*. This is often referred to as a *hard core* in the nucleon-nucleon potential, whose radius, it turns out, has to be taken as,

$$r_c \approx 0.5\ fm \tag{273}$$

to fit the scattering data. It should be emphasized however, that *all we really know is that the interaction becomes repulsive at such short distances,* but whether it really takes the form of an infinite repulsive hard core, or whether it takes other possible forms, we do not really know at this stage. It is this repulsive part in the nucleon-nucleon interaction that is in part responsible for the saturation of nuclear forces.

At the end of these citations from Refs. [15], [17], [18], we shall cite deShalit and Feshbach's concluding sentence about nuclear force: ”Our understanding of nuclear forces is still rather limited.”

In the conclusions of this book besides the other items, we will offer alternative answers to the questions listed here about nuclear forces, based on the concepts of the proposed new Superluminary Relativity Theory and on the principles of the Quantum Mass Theory [4].

2.1 Muons and pions

In Subsection 4.1 basic assumptions for Superluminary Relativity concepts of nuclear forces are given. According to the fifth assumption, in the deuteron nucleus, binding energy is connected with the emission and absorption of mesons or muons. Now, we have to find out what kind of particles they could be.

A maximum distance over which a virtual meson can carry momentum is [15], [17], [18],

$$r = \frac{h}{m_p} \approx 1.4 \cdot 10^{-15} = 1.4 \ fm \qquad (274)$$

where m_p is the mass of *p* - meson.

This distance is taken as a maximum distance between two nucleons where nuclear forces are effective. However, the distance between the proton and the neutron is,

$$r_d = 4 \cdot 10^{-15} \ m = 4 \ fm \qquad (275)$$

In our analysis for application of the theory of the system *g* ', to the deuteron nucleus, we shall consider two possibilities of what kind of particles besides proton and neutron may participate in the deuteron nucleus: *p* - mesons, that is pions, and muons. We found it necessary to investigate the possibility of a muonic type of binding energy in the deuteron nucleus despite the generally accepted assumption that muons can not participate into nuclear structures [15], [17]. The main reason for this new approach is the basic assumption for the presented new theory for system *g* ', that **conservation laws should be preserved**. As a contrast to this, according to current theories, in the nucleus where virtually every exchanged particle has a mass of *p* - meson, there is *a minimum* amount by which **energy conservation must be violated** [15]:

$$\Delta E > m_p \, c^2 \qquad (276)$$

where m_p is mass of the lightest known meson that is strongly coupled to the nucleons [15]:

$$m_p = 2.48 \cdot 10^{-28} \ kg \qquad \text{(charged pions)} \qquad (277)$$

$$= 2.40 \cdot 10^{-28} \ kg \qquad \text{(neutral pions)} \qquad (278)$$

and their energies are,

$$m_p \, c^2 = 139576 \pm 0.011 \ MeV \qquad \text{(charged pions)} \qquad (279)$$

$$= 134.972 \pm 0.012 \ MeV \qquad \text{(neutral pions)} \qquad (280)$$

That means that there is an upper limit to the time a virtual meson can stay away from its source:

$$\Delta t < \frac{\hbar}{m_p \, c^2} \qquad (281)$$

and there is consequently a maximum distance over which it can carry momentum:

$$\Delta r < c\,\Delta t = \frac{\hbar}{m_p\ c} \approx 1.4 \cdot 10^{-15} = 1.4\ fm \tag{282}$$

The range of nuclear forces is thus naturally related to the mass of the lightest observed meson [15], [17].

Because we would like to elaborate on the version with the presence of muons in the deuteron nucleus, Equation (281) for muons yields,

$$r = \frac{\hbar}{m_m\ c} = 1.868 \cdot 10^{-15}\ m = 1.868\ fm \tag{283}$$

where,

$$m_m = 1.88 \cdot 10^{-28}\ kg \tag{284}$$

is the mass of the muon, and its energy is [15],

$$E_m = 105.659 \pm 0.002\ MeV \tag{285}$$

Equation (283) gives some larger distance over which muons can carry momentum than corresponding *p* - meson. This is the first magnitude which is in favour of the muon's presence in the deuteron nucleus rather than the pion's presence. This will be supported again in Subsection 7, of this section.

3. PRINCIPLES OF QUANTUM MASS THEORY APPLIED TO SUPERLUMINARY FRAME OF REFERENCE *g* '

Quantum Mass Theory gives a new insight into the phenomena connected with photon-electron interactions [4]. There are two main results obtained by applications of this theory to the mentioned phenomena: new properties of the atom and new properties of the vacuum. The quantitative results obtained by the analysis based on QMT principles suggested new experiments by which *X* and *g* -rays are detected from ionized gasses. The experiments performed have shown that detected *X* and *g* -rays are emitted from the electronic system of the atom, as a result of electronic transitions predicted by QMT principles. The results of the experiments are in very good accordance with computed values of the observed magnitudes that could be considered as good verification of basic QMT principles.

Quantum Mass Theory is based on six main principles [4]:

1. In the photon-electron interaction, mass conservation and mass quantization principles are valid.
2. In the photon electron interaction there is photon capture by the electron.

3. The quantization of the momentum conservation law.

4. In the distances determined by atom dimensions there is an antigravitational field.

5. Quantization of angular momentum.

6. In the electron transitions from a higher to a lower state, there are two possibilities: the first one is when the optical frequency photon is emitted, and second is when the emitted photon is with energy in the X and g -ray region.

These six QMT principles create a new photon-electron interaction model. There are two main features of this new model, which will be used in this analysis, for the proton-neutron system.

The first one is that electron mass in an atomic system depends on its position relative to the nucleus. It means that there is an exchange of the masses between these two particles. This corresponds to contemporary theories for exchange of the masses and charges in the nuclei.

The second feature of the new photon-electron model, which will be used here, is the assumption that two particles have maximum interaction effect, if there is resonance between their deBroglie waves.

4. THE DEUTERON NUCLEUS - DESCRIBED AND EXPLAINED BY SUPERLUMINARY RELATIVITY AND QUANTUM MASS THEORY

In the analysis presented, three important pieces of data from current theories about the deuteron nucleus will be adopted:

a) The binding energy of the deuteron nucleus is, [15], [17]

$$E_b = 2.22\ MeV \tag{286}$$

b) There is mass and charge exchange between proton and neutron, which form the deuteron nucleus.

c) Nuclear forces in the deuteron nucleus, besides the other sources are due to the presence of mesons emitted by the proton and neutron which constitute the deuteron nucleus.

All other magnitudes of deuteron, will be derived by using SLR and QMT principles, and will be compared with values obtained by other theories and methods.

4.1 Basic assumptions

We shall start with our analysis by using the Fourth QMT principle [4]. According to this principle, in the atomic systems, between masses antigravitational force is acting, determined by the equation,

$$F_m = G' \frac{m_p m_n}{r^2} \tag{287}$$

where,

$$G' = -1.49 \cdot 10^{29} \ Nm^2 kg^{-2} \tag{288}$$

or,

$$G' \approx \frac{1}{\alpha} 10^{27} \tag{289}$$

where,

$$\alpha = \frac{1}{4\pi\varepsilon_o} \frac{e^2}{\hbar c} \approx \frac{1}{137} = 7.299 \cdot 10^{-3} \tag{290}$$

is fine structure constant, e is electron charge, c is velocity of light in the vacuum, and $\hbar$ is Planck's constant divided by 2π, and ε_o is vacuum permittivity.

In Ref. [4] that the initial idea for the existence of repulsive force between masses with certain distances between them is explained, as a contrast to the attractive Newton's gravitational force at a certain distance, proposed initially by R. Boscovich in his famous work "Theoria Philosophia Naturalis" (1758) [20]. The essential difference between Boscovich's general idea for repulsive force, and antigravitational force defined by QMT is, that it is possible to compute this magnitude and to define the distances where it acts, and to apply it to the new atomic system.

According to the law of universal gravitation formulated by Newton, the force of gravitation is given by the expression,

$$F = G_n \frac{m_1 m_2}{r^2} \tag{291}$$

where,

$$G = 6.67 \cdot 10^{-11} \ N \, m^2 \, kg^{-2} \tag{292}$$

is gravitational constant, and m_1 and m_2 are the masses of the two bodies at the mutual distance r.

If we compare Equations (287) and (291), it is obvious that actually it is the same as Newton's gravitation law, and the only difference is in the gravitational constants, *G'* **and** *G***.** Dependent on these constants, there is antigravitational or gravitational force between the masses of two bodies. These constants correspond to certain vacuum properties of the space where these two bodies are located.

The second part of the Fourth QMT principle states,

$$F_m = -F_e \tag{293}$$

where F_e is the attractive Coulomb force between charges in atomic systems.

Now, we may define the assumptions for nuclear forces, which will be applied in the theory for Superluminary Relativity.

First assumption

We shall consider the case when the free proton and the free neutron are approaching each other.

At the very beginning, before the proton and neutron achieve a certain distance between them, they are with their natural charges: +e of the proton, and 0-charge of the neutron. When the phenomena of proton-neutron scattering is considered by current theories, it is assumed that there is charge exchange between these particles. We shall dedicate a separate subsection to scattering phenomena, but now we shall formulate our definition for charge exchange between the particles, which will be verified by the results of the analysis.

After reaching a certain distance, the proton and neutron start to exchange their charges gradually. The final result is, both particles will have an equal quantity of positive charge.

It is important to point out that, the concept for charge exchange is not thoroughly elaborated on and explained in current literature, at least to the best of our knowledge.

Our concept for charge exchange, implies the possibility of the fundamental charge *e*, in certain circumstances, being divided into two halves, carried by the proton and neutron. This supposition will be explained and verified in the subsection for proton-neutron scattering.

Now we may define the **first assumption**:

The proton and neutron keep their electric properties only up to the certain distance between them. After reaching that certain distance, both particles start to exchange their charges, with the final result, that they have the same kind and same quantity of the charge, i.e., +e/2, when they reach the critical distance. Thus,

$$q'_p = q'_n = \frac{e}{2} = 0.8 \cdot 10^{-19}\ C \tag{294}$$

where,

q'_p - is the charge of the proton,

q'_n - is the charge of the neutron, and

$e = 1.6 \cdot 10^{-19}$ C is the fundamental charge.

<u>Second assumption</u>

Quantum Mass Theory, as we have already stated, initially was developed for atomic systems. Here, we want to apply, some of the principles of this theory, to the very important part of the atomic system, the nucleus. For atomic systems, QMT has been based and developed on a very important starting assumption: properties of the vacuum are not restricted only to the distances,

$$r < l_e = \frac{h}{m_e c} = 2.4262 \cdot 10^{-12}\ m \tag{295}$$

as is assumed in quantum electrodynamics and quantum chromodynamics, but there must be some vacuum properties for distances,

$$r > l_e \tag{296}$$

where l_e is the Compton wavelength of the electron.

That means, if the vacuum has certain properties when particles are apart from each other at a distance less than l_e, then it seems quite legitimate to assume that the vacuum should have certain properties also when the particles are separated by distances bigger than l_e, simply because of the space-time continuity. These properties are very likely to be different, but it is important that they exist. Ref. [4] shows what the vacuum properties are at distances:

$$r > l_e = 2.4262 \cdot 10^{-12}\ m$$

and how they influence the photon-electron interactions.

For comparison, it is good to remind ourselves that Bohr radius in the hydrogen atom is,

$$r = 0.5 \cdot 10^{-10}\ m \tag{297}$$

Now, we are interested in vacuum properties for distances,

$$r < l_e = 2.4262 \cdot 10^{-12}\ m$$

and how they can be defined by the QMT principles.

Our task is to try to offer new approach for the explanation of the properties of the nucleus and particles which constitute the nucleus by taking into account the vacuum properties of the space occupied by the nucleons and nucleus as a whole. To do that it will be necessary to define the space where all this is happening.

The Compton wavelength of the proton is,

$$l_p = 1.3214 \cdot 10^{-15}\ m$$

We will take the Compton wavelength of the proton rather than the Compton wavelength of the neutron, simply because the proton could be considered as a main part of the nucleus, without neglecting the importance of the neutron as a constitutive part of the nucleus.

Thus, we shall consider part of the space determined by the limits,

$$l_e = 2.4262 \cdot 10^{-12}\ m \tag{298}$$

and

$$l_p = 1.3214 \cdot 10^{-15}\ m \tag{299}$$

Hence, we shall consider distances,

$$l_e = 2.4262 \cdot 10^{-12}\ m > r > l_p = 1.3214 \cdot 10^{-15}\ m \tag{300}$$

Thus, the **second assumption** is:

Vacuum properties in the part of space defined by the limits l_e and l_p have influence on the properties of the nucleus, and consequently have influence to the nuclear reactions as well.

Third assumption

The analysis and experimental results presented in Ref. [4], show that there is exchange of the masses between proton and electron. Actually, it shows, that an electron in an interaction with photon, incorporates its mass, but the total mass of the electron depends also, on its position, i.e., on its distance from the proton. †

The third assumption is:

The proton and neutron which build the deuteron nucleus, exchange their masses and after achieving a certain distance between them, their masses will be equal, that is,

$$m'_p = m'_n = m' = \frac{m_p + m_n}{2} = 1.673445 \cdot 10^{-27}\ kg \tag{301}$$

where,

$$m_p = 1.67252 \cdot 10^{-27}\ kg \tag{302}$$

is proton mass, and

$$m_n = 1.673437 \cdot 10^{-27}\ kg \tag{303}$$

is neutron mass [15].

The distance, at which it happens, will be determined by the analysis presented here.

Fourth assumption

In the QMT, for the atomic systems, where the attractive Coulomb force is playing a very important role, as we have seen already, it is assumed, that a force exists with equal value to the Coulomb force, but with the opposite sign, the repulsive, antigravitational force [4].

According to our First assumption, in the deuteron nucleus, the proton and neutron have the same charge +e/2, and repulsive Coulomb force is acting.

According to QMT, there should emerge a force opposite to the direction of the acting Coulomb force, i.e., attractive force between the masses of the particles. This means, **again Newton's gravitational force between masses will appear, but with a different gravitational constant because of the distance between the masses and as a result of vacuum properties for such range of the space.**

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† The detailed analysis in Ref. [4] has been performed for a hydrogen atom, but the equations obtained have been modified for heavier atoms, which has been experimentally verified.

The fourth assumption is:

a) In the distances,

$$l_e > r > l_p \tag{304}$$

between the proton and neutron masses, i.e., m_p and m_n respectively, Newton's gravitational attractive force acts,

$$F_m = G'_n \frac{m_p m_n}{r^2} \tag{305}$$

where G'_n is the gravitational constant for part of the space determined by the expression (304). The value of this constant will be determined by the analysis.

b) No one of the forces should prevail, because in such case the particles should either collapse on each other, or will be separated that much that they will not constitute a deuteron nucleus. Therefore we will assume, that the total attractive force should be equal to the total repulsive forces, i.e.,

$$F_{attractive} = -F_{repulsive} \tag{306}$$

It means that the total energy of the attractive forces will be equal to the total energy of the repulsive forces. In such cases, nucleons that constitute the deuteron nucleus, the proton and neutron will be in a stable equilibrium state. That state will be determined by the binding energy too, and the latter equation becomes,

$$E_{binding} = E_{attractive} = E_{repulsive} \tag{307}$$

<u>Fifth assumption</u>

The **fifth assumption** is:

The proton and neutron in the deuteron nucleus emit binding particles (pions or muons), that participate in binding forces and binding energy. Each nucleon, both the proton and the neutron emit one particle separately. The binding particle emitted from one nucleon is absorbed from another one, which again emits a binding particle. We shall consider that these processes with pions or muons are not virtual but rather real ones.

Sixth assumption

The **sixth assumption** is:

If there is resonance between the meson's and nucleon's deBroglie waves, the condition for maximum effect of interaction between particles is preserved by this, according to Quantum Mass Theory [4] and the Theory of Magnetic and Electric Susceptibilities for Optical Frequencies [21].

4.2 Proton-neutron interaction

Let us consider the situation when the proton and neutron are approaching each other, as it is presented in Fig. 9. When they reach the positions a and b respectively, the distance r_o between them should be,

$$r_o \le l_e = 2.4262 \cdot 10^{-12} \ m \tag{308}$$

At this distance we can use Equations (287) and (288), to compute the attractive force between the two particles, as the only force acting between them at this point.

We shall suppose that the proton and neutron brought to the mutual distance r_o by the force F_m, will establish an unstable system with binding energy,

$$E_b = 2.22 \ MeV \tag{309}$$

At the distance r_o the only acting force between nucleons is gravitational force,

$$F_m = G' \frac{m_p m_n}{r_o^2} \tag{310}$$

where,

$$G' = 1.49 \cdot 10^{29} \ Nm^2 kg^{-2} \tag{311}$$

is the positive gravitational constant.

Hence, the only energy of the system is the energy of the gravitational field,

$$E_m = G' \frac{m_p m_n}{r_o} \tag{312}$$

If we assume the energy of the gravitational field E_m and binding energy E_b are equal, that is,

$$E_m = E_b \tag{313}$$

then we are in a position to compute the mutual distance between nucleons. The obtained value is,

$$r_o = 1.1688 \cdot 10^{-12}\ m \tag{314}$$

It is evident that,

$$r_o < l_e = 2.4262 \cdot 10^{-12}\ m \tag{315}$$

The attractive force between the proton and neutron at this distance is,

$$F_m = 0.41726\ N \tag{316}$$

It is obvious that,

$$r_o > l_p = 1.3214 \cdot 10^{-15}\ m \tag{317}$$

By this, the second assumption of the theory presented is satisfied, the particles are inside the range of the space,

$$l_e > r > l_p$$

where it is supposed that vacuum properties will be different from those predicted by QMT for distances,

$$r > l_e$$

and now Equation (310) should be used.

It seems to be justified to suppose that vacuum properties can not change abruptly immediately after the distance

$$l_e = 2.4262 \cdot 10^{-12}\ m$$

but rather gradually, approaching the distance,

$$l_p = 1.3214 \cdot 10^{-15}\ m$$

Therefore, because the distance,

$$r_o = 1.1688 \cdot 10^{-12}\ m \tag{318}$$

is close to the distance l_e , we may suppose that it is also justified to use Equations (310) and (311), to compute the magnitudes which define this unstable system of the proton and neutron.

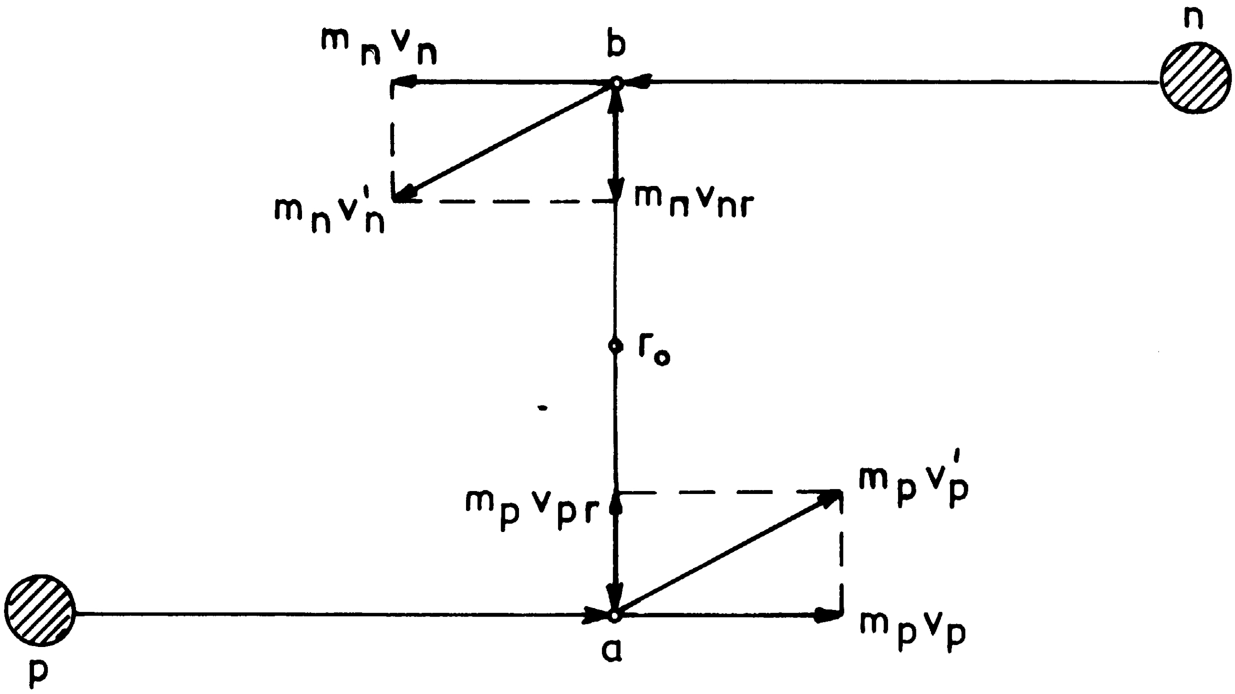


Fig. 9 Proton - *p*, moving towards the point a and neutron - *n*, moving towards the point b. Incidental, gravitational and resultant momenta are presented at points a and b, when the proton and neutron, respectively, reach these points.

Fig. 9, shows that at points a and b, the proton and neutron respectively will gain resultant momenta.

Resultant momentum for the proton for the point a is,

$$m_p \vec{v'}_p = m_p \vec{v}_p + m_p \vec{v}_{pr} \tag{319}$$

where,

$m_p \vec{v}_p$ - is proton momentum in the direction of its incidence, and,

$m_p \vec{v}_{pr}$ - is proton momentum caused by the force F_m.

The resultant momentum of the neutron at the point b is,

$$m_n \vec{v}'_n = m_n \vec{v}_n + m_n \vec{v}_{nr} \tag{320}$$

where,

$m_n \vec{v}_n$ - is neutron momentum in the direction of its incidence, and,
$m_n \vec{v}_{nr}$ - is neutron momentum caused by the force F_m.

Fig. 9, clearly shows that, proton and neutron resultant momenta produce torque which make particles rotate around a certain point, which actually is the mass centre of both particles.

Fig. 10a shows the position of the mass centre C_m of the proton and the neutron. By computation the distance l_p between the proton and mass centre C_m is obtained,

$$l_p = 0.58473 \cdot 10^{-12}\ m \tag{321}$$

and the distance l_n between the neutron and mass centre C_m , is,

$$l_p = 0.58407 \cdot 10^{-12}\ m \tag{322}$$

Because of the rotation of the particles, new forces will emerge - the centrifugal, which will have the same value and line of action with F_m , but the opposite direction.

Because of this, the proton and neutron constitute a system of two particles, but still it is not a deuteron nucleus, not only because it is an unstable system but also because it has different main magnitudes from those of a deuteron. In order to see what happens further with this system, first of all, it is necessary to compute the velocities of the particles and the corresponding attractive F_m and repulsive F_c centrifugal forces.

Fig. 10b, shows the system of two particles, the proton and neutron, at distance,

$$r_o = 1.1688 \cdot 10^{-12}\ m$$

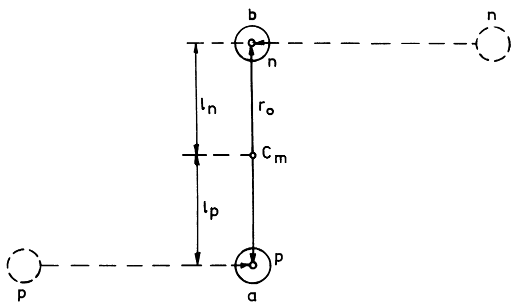
Each particle, proton and neutron have their tangential velocities, v_p and v_n presented, respectively, and the forces which act on them F_{mp} , F_{cp} and F_{mn} , F_{cn} presented, respectively, too.

At the point a, two forces act upon the proton, the attractive force F_{mp} and the repulsive, centrifugal force F_{cp} . Where,

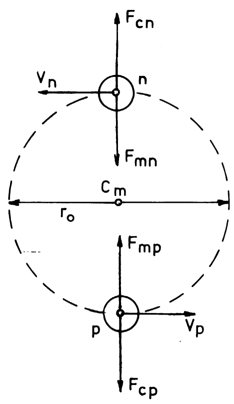
$$F_{mp} = -F_{cp} \tag{323}$$

At the point b, two forces also act upon the neutron, the attractive force F_{mn} and the repulsive, centrifugal force F_{cn} . Where,

$$F_{mn} = -F_{cn} \tag{324}$$



a)



b)

Fig. 10a When the proton - p and neutron - n, reach the points a and b, respectively, the distance between them is r_0. C_m is mass centre of the nucleons. l_p is the distance between the proton - p and C_m, and l_n is the distance between the neutron - n and C_m.

Fig. 10b F_{mp} and F_{mn} are attractive gravitational forces acting on the proton and neutron, respectively; F_{cp} and F_{cn} are repulsive centrifugal forces acting on the proton and neutron, respectively; v_p and v_c are tangential velocities of the proton and neutron, respectively.

According to Equation (313), the energy of the gravitational field and binding energy are equal for this two nucleon system, hence, potential and kinetic energies of these particles are equal, and they are also equal to the binding energy, that yields,

$$\sum E_{pot} = \sum E_{kin} = E_b = 2.22\ MeV \tag{325}$$

where E_b is binding energy.

The total potential energy is,

$$\sum E_{pot} = G' \frac{m_p\, m_n}{r} \tag{326}$$

The kinetic energy of the proton, at point a, is,

$$E_{kp} = \frac{m_p \left(v'_p\right)^2}{2} = \frac{l_p}{r_o} E_b \tag{327}$$

Out of the latter equation, the tangential velocity of the proton in its rotation around the mass centre C_m is,

$$v'_p = \sqrt{\frac{2\, l_p\, E_b}{m_p\, r_o}} \tag{328}$$

or,

$$v'_p = 2.4428 \cdot 10^6\ m/s \tag{329}$$

For the neutron at the point b, the kinetic energy is,

$$E_{kn} = \frac{m_n \left(v'_n\right)^2}{2} = \frac{l_n}{r_o} E_b \tag{330}$$

and the tangential velocity in its rotation around the mass centre C_m is,

$$v'_n = \sqrt{\frac{2\, l_n\, E_b}{m_n\, r_o}} \tag{331}$$

or,

$$v'_p = 2.3507 \cdot 10^6\ m/s \tag{332}$$

The comparison of the velocities of the proton and neutron, shows,

$$v_p > v_n \tag{333}$$

The values of the velocities for both particles that make up this two particle system, show that this process can be treated as non relativistic.

To find out whether the system is stable or not, it is necessary to compute the forces which act upon both particles which constitute the system.

As is shown in Fig. 10b, at the point a, two forces act on the proton which are in the same line but with opposite direction. The force of attraction is,

$$F_{mp} = \frac{l_p}{r_o} F_m \tag{334}$$

which yields,

$$F_{mp} = 0.1528\ N \tag{335}$$

The centrifugal force, which acts upon the proton at the point a, is,

$$F_{cp} = \frac{m_p \left(v'_p\right)^2}{l_p} \tag{336}$$

or,

$$F_{cp} = 0.01707\ N \tag{337}$$

It is obvious that,

$$\left|F_{mp}\right| \rangle\rangle \left|F_{cp}\right| \tag{338}$$

For the neutron at the point b, the force of attraction is,

$$F_{mn} = \frac{l_n}{r_o} F_m \tag{339}$$

or,

$$F_{mn} = 0.1524\ N \tag{340}$$

The centrifugal force acting upon the neutron at the point b, is,

$$F_{cn} = \frac{m_n \left(v'_n\right)^2}{l_n} \tag{341}$$

or,

$$F_{cn} = 0.0158\ N \tag{342}$$

It is also obvious, that

$$|F_{mn}| \rangle\rangle |F_{cn}| \tag{343}$$

Both forces which act over the particles, F_m - the attractive force, and F_c - the centrifugal force, are in fact, central forces. We shall consider F_m - the attractive force, as a centripetal force, which makes the particles rotate, and F_c - the centrifugal force as a repulsive force.

Equations (338) and (343) show that this system is not in a stable state, because for both particles the attractive forces F_{mp} and Fmn are larger than the corresponding repulsive forces F_{cp} and F_{cn}. This means, that the attractive forces make the proton and neutron continue to approach each other, until a certain distance between them is reached, and the system gains a stable state. This will not be sufficient for the proton-neutron system to become a deuteron nucleus. What else is necessary for the deuteron nucleus to be constituted, will be shown in the following analysis.

Each dynamically unstable system has a tendency to turn into a stable dynamic system. This proton-neutron system should have such a tendency, when the particles are apart from each other at the distance,

$$r_o = 1.1688 \cdot 10^{-12}\ m$$

In order to determine the magnitudes, which make the system, become stable it is necessary to apply the suppositions of this theory.

In order to determine the stable state of the proton-neutron system, and the structure of the deuteron nucleus, it will be necessary first of all to determine the vacuum properties in the range of the space limited by the distances,

$$l_e > r > l_p$$

5. ENERGY LEVELS IN THE SUPERLUMINARY FRAME OF REFERENCE *g* ’

According to the second assumption of the theory for system *g* ’, vacuum properties of the space determined by the boundaries l_{ce} and l_{cp}, have influence on the properties of the nucleus, and consequently influence on the nuclear reactions as well.

The results of the analysis presented in Table 2, show that this space can be divided into five energy levels, which correspond to the five values of the gravitational constant $G'n$, determined by quantum number n, and to five distances r.

T a b l e 2

Quantum Number	G_n' [N m^2 kg^{-2}]	Energy Levels	r (m)
		• • • • •	a) $\lambda_{ce} = 2.4262\ 10^{-12}$
0	$G' = 1.49 \cdot 10^{29}$	————	$r' = 1.1688 \cdot 10^{-12}$
1	$G_1' = 3.314 \cdot 10^{28}$	————	$r_1 = 2.6 \cdot 10^{-13}$
2	$G_2' = 7.373 \cdot 10^{27}$	————	$r_2 = 5.78 \cdot 10^{-14}$
3	$G_3' = 1.64 \cdot 10^{27}$ $G_d = 4.6 \cdot 10^{26}$	———— • • • • •	$r_3 = 1.28 \cdot 10^{-14}$ b) $r_d = 4.0 \cdot 10^{-15}$
4	$G_4' = 3.64 \cdot 10^{26}$	———— • • • • • • • • • •	$r_4 = 2.86 \cdot 10^{-15}$ c) $\lambda_{cp} = 1.32\ 10^{-15}$ d) $r_p = 8.13\ 10^{-16}$
5	$G_5' = 7.48 \cdot 10^{25}$	————	$r_5 = 6.36 \cdot 10^{-16}$
6	$G_6' = 1.66 \cdot 10^{25}$	————	$r_6 = 1.4 \cdot 10^{-16}$

a) electron Compton wavelength;
b) distance between nucleons in deuteron nucleus
c) proton Compton wavelength;
d) proton radius.

In Table 2, energy levels for two distances $r_5 = 6.36 \cdot 10^{-16}$ m and $r_6 = 1.415 \cdot 10^{-16}$ m which are under the limit l_{cp} are also presented. This table covers seven energy levels altogether. In Table 2 and positions of l_{ce} and l_{cp}, the proton radius r_p , and the proton-neutron distance r_d in the deuteron nucleus are also presented.

The values for G'_5 and G'_6 are computed for distances less than the radius of the proton. The reason is that each nucleus and consequently each particle has *surface thickness*. We shall cite deShalit and Feshbach here: Because the nuclear density, and also particle density, does not change abruptly from its nominal value to zero outside the nucleus and particle, there is a finite region called the *nuclear surface* (that is *particle surface*). The width of that region labeled with s is defined to be distance over which the density drops from 0.9 of its value at r = 0 to 0.1 of that value. Empirically s is a constant [15], [17],

$$s \approx 2.4 \ fm \tag{344}$$

For many nuclei s is approximately,

$$s = 0.2 \ r \tag{345}$$

where r is the nucleus or particle radius.

Thus, for a proton which has the radius,

$$r = 8.13 \cdot 10^{-16} \ m \tag{346}$$

the surface thickness will be,

$$s = 1.742 \cdot 10^{-16} \ m \tag{347}$$

and the difference is,

$$r - s = 6.38 \cdot 10^{-16} \ m \tag{348}$$

Hence, we have computed G'_5 and G'_6 for distances, which go slightly beneath the surface thickness of the proton.

As is shown in Table 2, when the neutron is approaching the proton, only by the attractive force because of the presence of the gravitational field between masses of these two particles, the attractive force will depend on the gravitational constant for a certain distance. For instance, when the neutron and the proton reach the distance $r_3 = 1.28 \cdot 10^{-14}$ m, the gravitational constant will be $G'_3 = 1.64 \cdot 10^{27}$ $N\ m^2 kg^{-2}$.

The values of the gravitational constants are determined by the expression,

$$G'_n = \frac{G'}{(4.495)^n} \tag{349}$$

where n is an integer from 1 to 6, and could be considered as the principal quantum number for this system. The latter equation can be expressed by the fine structure constant,

$$G'_n \approx \frac{G'}{\left(\frac{1}{30a}\right)^n} \tag{350}$$

Hence, we may introduce a new fine structure constant for nuclear systems, in this case for the proton-neutron system. This constant could be considered as a magnitude, which expresses properties of the proton-neutron system and the surrounding space. This magnitude is,

$$a' = \frac{1}{30a} \tag{351}$$

the **nuclear fine structure constant**.

T a b l e 3

n	0	1	2	3	4	5	6
α’	1	4.55	20.8	95	434	1984	9061

In Table 3 the values of a' for quantum numbers from $n = 0$ to $n = 6$ are presented.

Thus, Equation (349) becomes,

$$G'_n \approx \frac{G'}{(a')^n} \tag{352}$$

The distances r_n which correspond to certain gravitational constants G'_n are determined by the equation,

$$r_n = \frac{r'}{(4.495)^n} \tag{353}$$

or,

$$r_n = \frac{r'}{(a')^n} \tag{354}$$

The equation for gravitational attractive force now is,

$$F_{mn} = G'_n \frac{m_p m_n}{r_n^{\,2}} \tag{355}$$

which can be written in the form,

$$F_{mn} = (a')^n G' \frac{m_p m_n}{(r')^2} \tag{356}$$

The equation for gravitational field energy is,

$$E_{mn} = G'_n \frac{m_p m_n}{r_n} \tag{357}$$

or,

$$E_{mn} = E_m = G' \frac{m_p m_n}{r_o} = 2.22 \ MeV \tag{358}$$

The acceleration of the gravitational field is defined by the equation,

$$g = G' \frac{m_p}{(r')^2} \tag{359}$$

Table 4 shows that, up to n = 4, the energy E_m is equal to the binding energy of the deuteron nucleus, that is,

$$E_m = 2.22 \ MeV \tag{360}$$

while for n = 5, the energy is,

$$E_{m5} = 2.06 \ MeV \tag{361}$$

and for n =6, the energy is,

$$E_{m6} = 2.047 \ MeV \tag{362}$$

Table 4

Quantum number	r_n (m)	E_m (*MeV*)	F_m (*N*)	F_e (*N*)
0	$1.16 \cdot 10^{-12}$	2.227	0.305	-
1	$6 \cdot 10^{-13}$	2.727	2.745	$8.54 \cdot 10^{-4}$
2	$5.78 \cdot 10^{-14}$	2.229	6.18	$1.74 \cdot 10^{-2}$
3	$1.28 \cdot 10^{-14}$	2.23	27.8	$3.5 \cdot 10^{-1}$
4	$2.86 \cdot 10^{-15}$	2.224	124.4	7.4
5	$6.36 \cdot 10^{-16}$	2.053	517.7	130
6	$1.4 \cdot 10^{-16}$	2.047	2321	2880

Table 4, explicitly shows that in all neutron positions towards the proton, the gravitational attractive force is much larger than the Coulomb repulsive force, i.e.,

$$\left|F_m\right| \rangle\rangle \left|F_e\right| \tag{363}$$

This is so until the distance between the two particles reaches the value,

$$r_6 = 1.415 \cdot 10^{-16}\ m \tag{364}$$

when the gravitational attractive force between the masses of these two particles is,

$$F_{m6} = 2340\ N \tag{365}$$

and the Coulomb repulsive force between them is,

$$F_{e6} = 2880\ N \tag{366}$$

It is obvious that,

$$\left|F_e\right| \rangle\rangle \left|F_m\right| \tag{367}$$

The last expression will be thoroughly elaborated upon in Section IV about proton-neutron scattering.

In this analysis the first assumption of the theory for g ’ system is applied, for the exchange of the charges between the particles, effective from the position when the neutron has entered the region l_{ce} - l_{cp} . Thus, for all distances from r_1 till the last one considered, i.e., r_6, it is assumed that both particles, proton and neutron, have charges,

$$q_p = q_n = \frac{e}{2} = 0.8 \cdot 10^{-19}\ C \tag{368}$$

Fig. 11 shows the curve of the function,

$$a' = f(n) \tag{369}$$

without keeping a proportional scale.

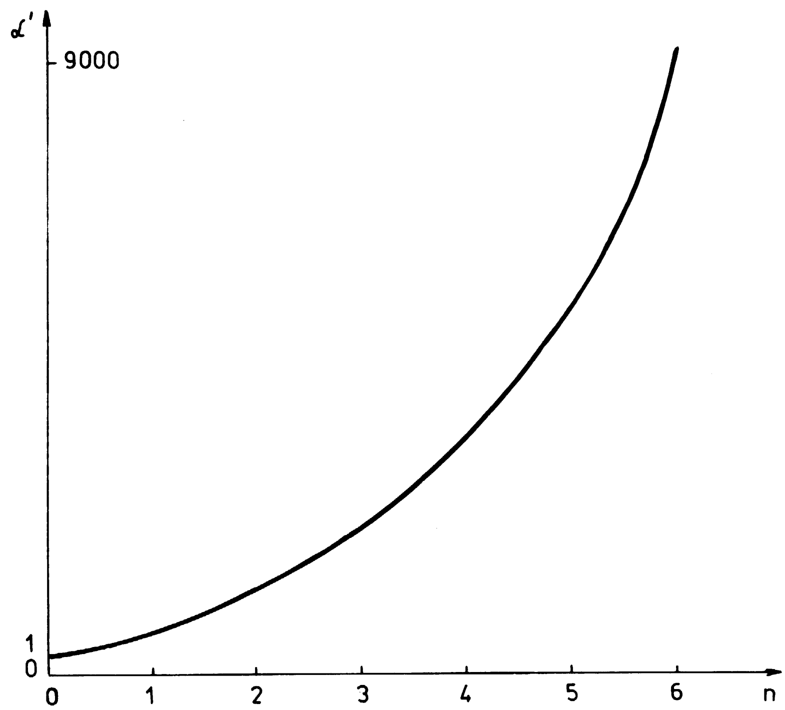


Fig. 11 The function α' = $f(n)$, where n is the principal quantum number.

The curve of the latter function we comprehend as a support to the analysis in the Subsection V/4 for the existence of the curvature of space-time in the range of space determined by the magnitudes l_{ce} and l_{cp} . This supposition may have important consequences for understanding the nuclear forces and nuclear processes. **The existence of the space-time curvature around the nuclei would**

mean that principles of General Relativity are valid not only for masses and distances characteristic for the universe, but also for masses and distances characteristic for nuclei.

6. INTERMEDIATE AND STABLE ENERGY STATES OF THE PROTON-NEUTRON SYSTEM

In Section II, the elaborated on imagined phenomena were based on the assumption of the presence of nuclear forces which cause nucleons to be within the range of their nuclear interaction, and which produce rotation of the nucleons and the residual particles of the reactions.

In the subsections III/3 and III/5 we have offered an explanation as to what the nature of the involved nuclear forces is, how they can be defined and computed by the SLR theory and by QMT.

Now, we have to apply the principles of SLR theory and principles of QMT, to compute magnitudes, which determine nuclear forces, as they are comprehended by these two theories, for the p - n system. We shall perform computations for two different energy states of the p - n system. After that, the obtained values of the magnitudes for the p - n system will be compared with the magnitudes, which characterise the deuteron nucleus. We shall see that inference of this comparison, in fact will be an offer for a new model of the deuteron nucleus.

Besides the explanations for nuclear forces according to the current theories in subsection III/2, we have to add the next citation from Ref. [15]: Most probably nuclear forces arise out of the strong coupling of the nucleons to the various mesons that have been discovered. This coupling is manifested through prolific production of mesons wherever a nucleon of high energy is decelerated. It is therefore reasonable to assume that nucleons can also emit virtual mesons, and by exchanging them they exchange the momentum that gives rise to a force between the nucleons.

The Fifth assumption for explanation of the deuteron nucleus by SLR theory and QMT, predicts the necessity for emission and absorption of mesons or muons in this nucleus. In system g, that is where $v < c$ and where Special Relativity principles are valid, we have seen that mesons are emitted from nucleons when they are decelerated. In the system g ' where $v > c$ it is the opposite, a nucleon emits a meson or muon when it is accelerated. The results of the analysis will show that this supposition is justified. The proton-neutron coupling in the system g ' is manifested through prolific production of mesons or muons, when nucleons are accelerated, and what is important **the energy conservation law is preserved**.

Now, we have to determine what kind of particles, mesons or muons, are taking part in this process. It has already been said in the subsection III/2.1 that the lightest known meson that is strongly coupled to the nucleon is π-meson or a pion.

Let us consider pion emission by neutron in the *p* - *n* system. A pion decays by the process,

$$p^{-} \rightarrow m^{-} + n_{m} \tag{370}$$

where,

p^{-} – is muon
n_{m} – is m-neutrino.

Now, we will come to the reactions which we have already used in Section II.

The neutron absorbs n_{m} and decays by the process,

$$n + n_{m} \rightarrow p' + m^{-} \tag{371}$$

This was Reaction No. 1 in the examples in the Section II. However, now we will have a situation when both reactions will take place together, and we have to make a distinction between the initial proton and initial neutron designated by *p* and *n*, respectively and the residual proton and residual neutron designated by *p*' and *n*', respectively. Thus, the latter expression shows that initial neutron *n* is turning into residual proton *p*'. The initial proton *p*, absorbs m^{-} and will turn into residual neutron *n*' and *m*-neutrino, according to the reaction,

$$p + m^{-} \rightarrow n' + n_{m} \tag{372}$$

This is Reaction No. 2 in Section II.

From the last two reactions described, *p* - *n* coupling will be comprehended as proton-neutron exchange of emitted pions and because of that the exchange of their momenta will take place.

It was convenient to use these two reactions separately in our imagined phenomena in Section II. There are two reasons why we cannot apply these processes in *p* - *n* system, by simple summation of their effects:

a) the mean life of pions is

$$T_{p} = 2.6 \cdot 10^{-8}\ s \tag{373}$$

when the distance between the proton and neutron is

$$r_d = 4 \cdot 10^{-15}\ m \tag{374}$$

the necessary time for the completion of one circle is,

$$T = 1.38 \cdot 10^{-23}\ s \tag{375}$$

This is too short a time, and the pion cannot decay by the described process.

b) Even if there is a situation with some other radius and other tangential velocity of nucleons, so that there will be enough time for the pion's decay, these processes cannot be accepted because in the *p* - *n* system there will be two m^- muons. In such a case charge parity will not be conserved.

Because of all this, it is necessary to consider the next possibilities for emission and absorption of coupling particles in the *p* - *n* system:

- p^- and p^+ mesons, that is, pions,
– m^- and m^+ muons, and,
– π^o meson (neutral pion).

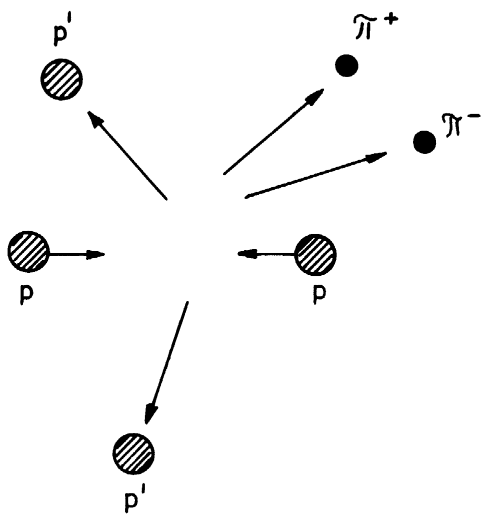


Fig. 12 Schematic presentation of the creation of two *p* - mesons, that is to say pions, in a high-energy collision of two protons. Incident protons are designated by *p*; protons after collision are designated by *p*'. p^+ and p^- are positive and negative pions, respectively. The total charge is conserved.

It is worthwhile describing here one known phenomenon with emission of pions and when the total charge is conserved [15]. Fig. 12 is a schematic presentation of prolific creation of two *pi* mesons, i.e., pions, in high energy collision with two protons. One pion carries the charge +e, and other -e, where e is the magnitude of the electronic charge. The total charge is thus conserved in this event.

This phenomenon is useful for us for two reasons:

- it explains what might happen when two nucleons with high energy interact, and,
- it is an example of charge parity conservation.

Firstly, we shall consider the case when the proton emits m^+ muon, while the neutron emits m^- muon. The results of the analysis show a very good accordance between the magnitudes of the considered *p - n* system and those of the deuteron nucleus.

Secondly, we shall consider the *p - n* system with p^- and p^+ pions. The comparison of the results of the analysis will lead to very interesting conclusions.

6.1 <u>Proton-neutron system with muons</u>

By the analysis attractive and repulsive forces between the participating particles in the analyzed phenomena will be computed.

Magnitudes of attraction:

- Magnitudes which determine gravitational effects:
  - the energy of the gravitational field,
  - the gravitational field, and
  - the attractive gravitational force.

Magnitudes of repulsion:

- the Coulomb repulsive force
  - the kinetic energy and centrifugal repulsive force.

6.1.1 *Intermediate energy state of p - n system*

Despite the fact that it is not possible to use directly the two reactions considered separately in Section II, for the reasons given, still here the same main physical objects, proton, neutron and muons, the same p - n distances, and the same, or tangential velocities of the same order of the objects will be used. Thus, in the following analysis very similar situations to the reactions used in the Section II will be analyzed.

The intermediate energy state of the p - n system is when the nucleons are in the position determined by the main quantum number n = 1, and the distance between the nucleons is,

$$r_1 = 2.6 \cdot 10^{-13} \ m \tag{376}$$

Table 2 shows that the next gravitational constant corresponds to this position,

$$G'_1 = 3.314 \cdot 10^{28} \ N\, m^2\, kg^{-2} \tag{377}$$

From Table 2 it is evident that distance r_1 is inside the region l_{ce} - l_{cp} and by that the conditions for application of the assumptions 1, 2 and 3 from the Subsection III/4.1 are fulfilled.

Thus, the proton and neutron masses now are,

$$m_p' = m_n' = m' = 1.673445 \cdot 10^{-27} \ kg \tag{378}$$

and charge exchange is already completed and the nucleons have the charges,

$$q_p' = q_n' = q' = \frac{e}{2} = 0.8 \cdot 10^{-19} \ C \tag{379}$$

where,

$$e = 1.6 \cdot 10^{-19} \ C \tag{380}$$

is the elementary charge.

Magnitudes of attraction

The energy of the gravitational field for this distance is given by the equation,

$$E_{m1} = G'_1 \frac{m_p'\, m_n'}{r_1} = G'_1 \frac{(m')^2}{r_1} \tag{381}$$

which yields,

$$E_{m1} = 3.569 \cdot 10^{-13} = 2.228 \ MeV \tag{382}$$

The gravitational field is,

$$g = G'_1 \frac{m_p'}{r_1} \tag{383}$$

which gives,

$$g = 8.2 \cdot 10^{27} \ m/s^2 \tag{384}$$

having the same dimensions with acceleration.

The attractive gravitational force is,

$$F_{m1} = G'_1 \frac{(m')^2}{r_1^2} \tag{385}$$

which yields,

$$F_{m1} = 2.745 \ N \tag{386}$$

Magnitudes of repulsion

Coulomb force

Between the proton and neutron with charges q_p' and q_n' the Coulomb force,

$$F_e = \frac{1}{4\pi \varepsilon_o} \frac{q_p' q_n'}{r_1^2} = \frac{1}{16\pi \varepsilon_o} \frac{e^2}{r_1^2} \tag{387}$$

will act. Which yields,

$$F_e = 8.54 \cdot 10^{-4} \ N \tag{388}$$

where,

$$\varepsilon_o = 8.8544 \cdot 10^{-12} \ N^{-1} m^{-2} C^2 \tag{389}$$

is vacuum permittivity.

Kinetic energy. Centrifugal forces

The tangential proton and neutron velocities at this mutual distance r_1 will be taken the same as the velocities in the reactions from Section II, for this distance, that is,

$$v_p = v_n = v_1 = 1.4 \cdot 10^7 \ m/s \tag{390}$$

Thus the total kinetic energy of the *p* - *n* system will be

$$E_{kin} = E_{(kin)p} + E_{(kin)n} \tag{391}$$

or,

$$E_{kin} = 2m'c^2 \left(\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 1 \right) \tag{392}$$

which yields,

$$E_{kin} = 3.27 \cdot 10^{-13} \ J = 2.04 \ MeV \tag{393}$$

The centrifugal force is,

$$F_{cent} = \frac{E_{kin}}{r_1} \tag{394}$$

which gives,

$$F_{cent} = 2.515 \ N \tag{395}$$

The total repulsive force will be,

$$F_{rep} = F_e + F_{cent} \tag{396}$$

which yields

$$F_{rep} = 2.5158 \ N \tag{397}$$

Conclusion:

When the proton and neutron find themselves at mutual distance,

$$r_1 = 2.6 \cdot 10^{-13} \ m \tag{398}$$

the attractive gravitational force is larger than the total repulsive forces which are the result of Coulomb and centrifugal forces. It has been found, that,

$$F_{attraction} = 2.745\ N \tag{399}$$

and

$$F_{repulsion} = 2.5158\ N \tag{400}$$

Hence,

$$\left|F_{attraction}\right| > \left|F_{repulsion}\right| \tag{401}$$

The consequence of this is an approaching of the nucleons until they reach the mutual distance, when the assumption 4 will be satisfied, that is,

$$F_{attraction} = -F_{repulsion} \tag{402}$$

At this point the proton-neutron system will be in the stable energy state and will constitute a deuteron nucleus.

6.1.2 *Stable energy state of p - n system. Deuteron nucleus*

Now we will consider the *p* - *n* system when distance between the nucleons is,

$$r_d = 4 \cdot 10^{-15}\ m \tag{403}$$

the distance which has been used in both reactions in Section II, when it was supposed that the nucleons had been driven from the distance r_1 , by nuclear forces. We owe explanations for those forces. In the analysis in the previous subsections and in this one, we actually show what the nature of those predicted nuclear forces is, how they can be defined and computed.

When the proton and neutron find themselves at the above given distance from each other, assumptions 1, 2 and 3 of the subsection III/4.1 are already satisfied.

Now we have to find out whether at this distance it will be possible to satisfy assumptions 4 and 5.

As we have stated in the introductory part of this subsection, nucleons will emit and absorb muons when they reach a certain distance with a certain kinetic energy. Fig. 13, shows a new model of the deuteron nucleus with proton, neutron and m^- and m^+ muons, which will be analyzed in this subsection.

Magnitudes of attraction

The energy of the muon is, [15], [17]

$$E_m = 105.659\ MeV \tag{404}$$

and its mass is,

$$m_m = 0.188 \cdot 10^{-27}\ kg \tag{405}$$

After emission of m^- and m^+ muons, the nucleons will have the masses,

$$m_p' = m_n' = m' = 1.485 \cdot 10^{-27}\ kg \tag{406}$$

The energy of the gravitational fields between all four participating objects in the *p* - *n* system, i.e., the two nucleons and two muons, is given by the next equation,

$$E_{md} = E_{mpn} + E_{mm} \tag{407}$$

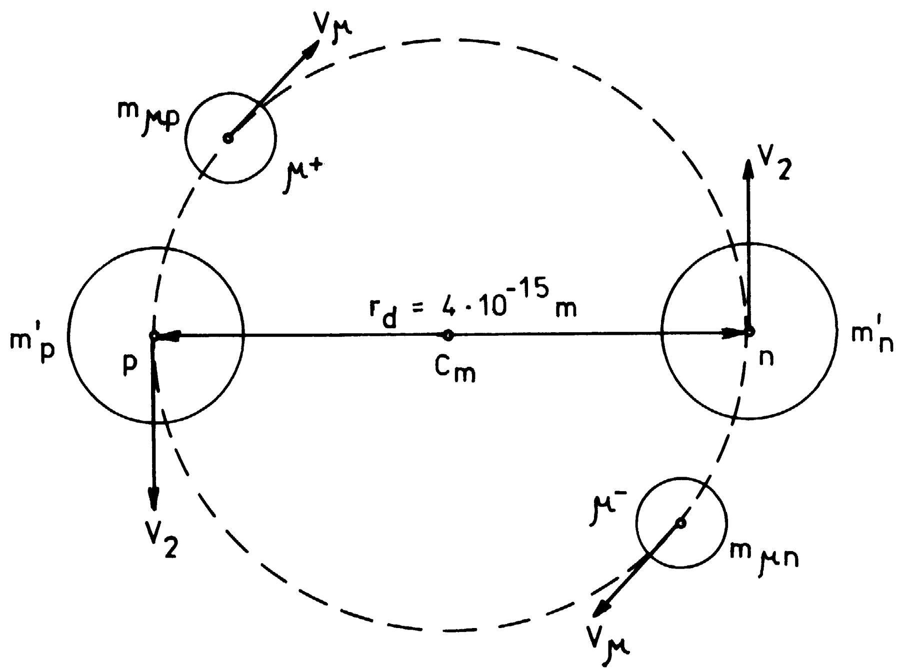


Fig. 13 The newly proposed deuteron nucleus model where $r_d = 4 \cdot 10^{-15}$ (m) is the distance between the proton - *p* and neutron - *n*. The proton and neutron are rotating with the same peripheral velocity v_2, in a circle with a radius $r_d/2$. Muons m^- *and* m^+ are rotating in the circle with the same radius $r_d/2$, but in the opposite direction, and with the same velocity v_μ. The mass centre C_m is on the half distance between the proton and neutron.

where,

$$E_{mpn} = G'_d \frac{m_p ' m_n '}{r_d} = G'_d \frac{(m')^2}{r_d} \tag{408}$$

is the energy of the gravitational field between the proton and neutron, and,

$$G'_d = 4.6 \cdot 10^{26} \ Nm^2 \ kg^{-2} \tag{409}$$

is the gravitational constant which represents the energy line between the two energy levels which correspond to the principal quantum numbers n = 3 and n = 4, as is presented in Table 2.

There is also,

$$E_{mm} = G'_d \frac{f\left(m', m_m\right)}{r_d} \tag{410}$$

the energy of the gravitational fields between the nucleons and muons. The function of the masses is,

$$f\left(m', m_m\right) = m_m{}^2 + \frac{2\left(m' m_m\right) + \left(2\, m'\right)\left(2\, m_m\right)}{2} = m_m{}^2 + 3 m' m_m \tag{411}$$

When this function is substituted into Equation (410), it becomes,

$$E_{mm} = G'_d \frac{\left(m_m\right)^2 + 3 m' m_m}{r_d} \tag{412}$$

Equation (408) for the energy of the gravitational field between the nucleons, yields,

$$E_{mpn} = 1.583 \ MeV \tag{413}$$

and Equation (410) for the energy of the gravitational fields between the nucleons and muons, and between the muons, yields,

$$E_{mm} = 0.626 \ MeV \tag{414}$$

When the latter two values are substituted into Equation (407), the total energy of the gravitational fields in the p - n system, will be obtained,

$$E_{md} = 2.21\ MeV \tag{415}$$

The deuteron nucleus binding energy is [15], [17], [18],

$$E = 2.22\ MeV \tag{416}$$

The comparison of these two values shows that accordance between computed and observed values of deuteron nucleus binding energy is 0.5%, which could be considered as a very good degree of accuracy.

Magnitudes of repulsion

Kinetic energy

We shall assume that the tangential velocities of the nucleons at the mutual distance,

$$r_d = 4 \cdot 10^{-15}\ m$$

are the same as the tangential velocities of the proton and neutron at this distance in Reaction No 1. and Reaction No. 2, in Section II, that is,

$$v'_p = v'_n = v = 4.533 \cdot 10^8\ m/s \tag{417}$$

The tangential velocity of muons is,

$$v_m = 3.96 \cdot 10^8\ m/s \tag{418}$$

Muons rotate in the opposite direction to nucleons.

Thus, the total kinetic energy of the *p* - *n* system with rotating nucleons and muons is,

$$E_{kin} = E_{kinpn} + E_{kinm} \tag{419}$$

where,

$$E_{kinpn} = 2m'c^2 \left(1 - \sqrt{1 - \frac{c^2}{v^2}}\right) M_c \tag{420}$$

is the kinetic energy of two nucleons. The latter equation yields,

$$E_{kinpn} = 1.92 \ MeV \tag{421}$$

Also,

$$E_{kinm} = 2\, m_m \, c^2 \left(1 - \sqrt{1 - \frac{c^2}{v^2}} \right) M_c \tag{422}$$

is the kinetic energy of the muons. The latter equation yields,

$$E_{kinm} = 0.337 \ MeV \tag{423}$$

In Equations (420), (422) it was assumed that,

$$M_c = 4.6 \cdot 10^{-3} \tag{424}$$

By substituting the values from Equations (421), (424) into Equation (419) the total kinetic energy of the *p* - *n* system is,

$$E_{kin} = 2.257 \ MeV \tag{425}$$

The energy of the electric field

Since in the rotating *p* - *n* system m^- and m^+ are rotating, the conservation of charge parity is preserved, and we may compute the energy of the electric field between the nucleons, by the equation,

$$E_e = \frac{1}{16 p e_o} \frac{e^2}{r_d} \tag{426}$$

which yields,

$$E_e = 9 \cdot 10^{-2} \ MeV \tag{427}$$

Conclusion:

The attractive force in the analyzed *p* - *n* system is gravitational force, and consequently the energy of the gravitational field is E_{md} , thus,

$$E_{att} = E_{md} = 2.21 \ MeV \tag{428}$$

The total repulsive force is the sum of centrifugal forces and the Coulomb force, hence, the total repulsion energy is,

$$E_{rep} = E_{kin} + E_e = 2.347\ MeV \tag{429}$$

The difference between the latter two values is 6.2%. Hence, we may conclude,

$$E_{attractive} = E_{repulsive} \tag{430}$$

Because the corresponding forces are given by the equations,

$$F_{attractive} = \frac{E_{att}}{r_d} \tag{431}$$

and,

$$F_{repulsive} = \frac{E_{rep}}{r_d} \tag{432}$$

we may also conclude, that,

$$F_{attractive} = -F_{repulsive} \tag{433}$$

The final conclusions of this subsection are:

The *p* - *n* system, analyzed by the principles of the presented SLR theory and by the principles of QMT from Ref. [4], can be considered as a proposal for a new model of the deuteron nucleus. A high degree accuracy in computed, compared to observed, values for two important magnitudes: the distance between nucleons and the binding energy, can be considered as a good support for the assumptions upon which the SLR theory presented is based.

However, the following analysis will also show very good accordance between the computed and observed values for other important magnitudes of deuteron nucleons, that is the magnetic moment, and a more acceptable new explanation of the *p* - *n* scattering phenomena.

Through the results of the presented analysis we practically offer a new approach to nuclear forces and a new insight into nuclear structures and processes.

Angular momentum

When it is necessary to determine the positions of the particles and their angular momenta, it is necessary to have in mind the *uncertainty principle* expressed by the relations [7], [15],

$$\Delta p \Delta r \geq \hbar \qquad (434)$$

where,

p - is angular momentum,
r - is the position of the particle,
Dp - is the root-mean-square error of p,
Dr - is the root-mean-square error of r, and
$\hbar = h/(2p)$ - h is Planck's constant.

The inequality asserts that the two variables p and r cannot be known more accurately than that the product of the "uncertainties" of the two variables is of the order of Planck's constant [7].

When the p - n system is in the energy level, which corresponds to the principal quantum number $n = 1$, the distance between the nucleons is,

$$r_1 = 2.6 \cdot 10^{-13}\ m \qquad (435)$$

and their tangential velocities are,

$$v_1 = 1.4 \cdot 10^7\ m/s \qquad (436)$$

The angular momentum for this energy state of the p - n system is,

$$p_1 = 2m' v_1 \frac{r_1}{2} \qquad (437)$$

which yields,

$$p_1 = 6.1 \cdot 10^{-33}\ kg\, m^2\ s^{-1} \qquad (438)$$

It has to be pointed out that this is an unstable state of the p - n system.

When the p - n system is at the stable energy state, the distance between the nucleons is,

$$r_d = 4 \cdot 10^{-15}\ m \qquad (439)$$

and their tangential velocities are,

$$v = 4.533 \cdot 10^{8}\ m/s \tag{440}$$

while the tangential velocity of the muons is,

$$v_m = 4.06 \cdot 10^{8}\ m/s \tag{441}$$

The nucleons and muons rotate in opposite directions, therefore the total angular momentum of the system will be,

$$p = p_m - p_m \tag{442}$$

where,

$$p_m = 2\,m'\,v\,\frac{r_d}{2}\sqrt{1-\frac{c^2}{v^2}} \tag{443}$$

is the angular momentum of the nucleons, and the latter equations yields,

$$p_m = 1.532 \cdot 10^{-33}\ kg\,m^2\,s^{-1} \tag{444}$$

The angular momentum of muons is given by the equation,

$$p_m = 2\,m_m\,v_m\,\frac{r_d}{2}\sqrt{1-\frac{c^2}{{v_m}^2}} \tag{445}$$

which yields,

$$p_m = 0.205 \cdot 10^{-33}\ kg\,m^2\,s^{-1} \tag{446}$$

According to Equation (442), the total angular momentum of the p - n system when it is in the stable energy state, is,

$$p = 1.33 \cdot 10^{-33}\ kg\,m^2\,s^{-1} \tag{447}$$

According to the angular momentum conservation law, the values of Equations (438) and (447) should be equal. In this case it is not possible to achieve that accuracy, for two reasons:

a) firstly because of the uncertainty principle,
b) secondly, although both computed angular momenta belong to the same p - n system, they correspond to two drastically different energy states of the system: unstable and stable.

Therefore, because the values of the angular momenta for positions r_1 and r_d are of the same order of magnitude, we may accept as sufficient proof that angular momentum conservation law is preserved.

6.2 The proton-neutron system with pions

Now we shall consider the possibility that in the p - n system instead of muons, the participating objects which give rise to the nuclear forces could be π^- and π^+ mesons, that is to say pions. In the introductory part of the subsection II/4 we have given data about the mean life of pions, i.e.,

$$T_p = 2.6 \cdot 10^{-8}\ s$$

When the distance between nucleons and mesons is,

$$r_d = 4 \cdot 10^{-15}\ m$$

then the necessary time for the completion of one circle is,

$$T_d = 1.3 \cdot 10^{-23}\ s \tag{448}$$

Therefore it is justified to assume that π-mesons emitted from the proton and neutron will not decay during their participation in the deuteron nucleus structure.

The energy of the gravitational field between the proton, neutron and two pions, will be computed by Equation (407), applied to the case with pions in p - n system, thus,

$$E_{md} = E_{mpn} + E_{mp} \tag{449}$$

where,

$$E_{mpn} = G'_d \frac{(m')^2}{r_d} \tag{450}$$

is the energy of the gravitational field between nucleons and the latter equation yields,

$$E_{mnp} = 1.3638\ MeV \tag{451}$$

The energy of the gravitational field among the nucleons and pions, and among the pions themselves, according to Equation (412) applied for the case with pions in the *p* - *n* system, is,

$$E_{mp} = G'_d \frac{(m_p)^2 + 3m'm_p}{r_d} \tag{452}$$

which yields,

$$E_{mp} = 0.802 \ MeV \tag{453}$$

The total energy of the gravitational fields in the deuteron nucleus with pions, will be,

$$E_{md} = 2.166 \ MeV \tag{454}$$

Since the deuteron nucleus binding energy is,

$$E_d = 2.22 \ MeV$$

the accordance between computed and observed values is 2.5%.
The mass of charged pions is,

$$m_p = 0.248 \cdot 10^{-27} \ kg \tag{455}$$

and masses of the nucleons after emission of pions are,

$$m'_p = m'_n = m' = 1.38 \cdot 10^{-27} \ kg \tag{456}$$

We shall assume that in this version with pions, nucleons will have the same tangential velocities as nucleons in the version with muons, that is,

$$v'_p = v'_n = v = 4.533 \cdot 10^8 \ m/s \tag{457}$$

and the pions will have the same tangential velocities of muons in the first version, thus,

$$v_p = 3.96 \cdot 10^8 \ m/s \tag{458}$$

The total kinetic energy of the deuteron nucleus will be computed by Equation (419), applied to the *p* - *n* system with pions, thus,

$$E_{kind} = E_{kinpn} + E_{kinp} \tag{459}$$

where,

$$E_{kinpu} = 2\,m'c^2 \left(1 - \sqrt{1 - \frac{c^2}{v^2}}\right) M_c \tag{460}$$

which yields,

$$E_{kinpn} = 1.7827 \; MeV \tag{461}$$

The kinetic energy of the two pions is,

$$E_{kinp} = 2m_p \; c^2 \left(1 - \sqrt{1 - \frac{c^2}{v^2}}\right) M_c \tag{462}$$

which yields,

$$E_{kinp} = 0.446 \, MeV \tag{463}$$

Hence, the total kinetic energy of the deuteron nucleus with pions, is,

$$E_{kind} = 2.227 \, MeV \tag{464}$$

The energy of the electrostatic fields between the charged particles will be the same as in the case with muons, because the same charges participate. Thus,

$$E_e = 9 \cdot 10^{-2} \; MeV \tag{465}$$

and the total energy of the repulsive forces is,

$$E_{rep} = E_{kin} + E_e \tag{466}$$

which yields,

$$E_{rep} = 2.317 \; MeV \tag{467}$$

Conclusions:

The energy of the gravitational field in the deuteron nucleus with pions is energy of attractive forces, thus we may write,

$$E_{att} = E_{md} = 2.166\ MeV$$

The total energy of the fields, which produce repulsive forces, is,

$$E_{rep} = E_{kind} + E_e = 2.317\ MeV$$

The difference between the latter two values is 7%, therefore we may conclude,

$$E_{attractive} = E_{repulsive}$$

and because,

$$F_{att} = \frac{E_{att}}{r}$$

and,

$$F_{rep} = \frac{E_{rep}}{r}$$

we may also conclude,

$$F_{attractive} = -F_{repulsive}$$

in the deuteron nucleus with pions.

As a contrast to this version with pions in the deuteron nucleus, as we have seen, in Subsection III/6.1.2, in the case with muons in the deuteron nucleus, the difference between the attractive and repulsive energies was 5%. That does not mean that we may give any advantage to the version with muons. The difference in the achieved accuracy is rather the result of systematic errors in computations, therefore the model with muons cannot be considered as more justified than one with the pions, merely on the strength of these results.

These results lead to the main conclusion:

The deuteron nucleus should be comprehended as the *p* - *n* system with two mesons in the nuclear structure, which take part in the binding energy and in the formation of nuclear forces. The results also show that all the participating objects in the deuteron nucleus, that is, two nucleons and two mesons, are rotating in a circle with the same radius. The mesons rotate in the opposite direction to the nucleon motion. That all these objects really rotate we have additional proofs in the following subsections.

Because both versions, one with muons and the other with pions give almost identically good results of the analysis, the question arises: which version prevails, and what might be the arguments which may help us to make such a conclusion? The important thing is that the new deuteron nucleus model proposed here, implies the participation of mesons in the deuteron nucleus structure. Whether they are *m*-mesons, that is muons, or π-mesons, that is, pions, does not have any influence at all on any of the main computed magnitudes, which characterise the new deuteron nucleus model. What is really important is the fact that the newly proposed deuteron nucleus model offers a completely new insight into nuclear forces and nuclear structures in general, which will be explained in more details in the final subsections and final conclusions of this book.

We do not find it productive to involve our analysis into further speculations which will include the decay of processes of muons and pions, and their mean lives in order to find out which version is more acceptable, that with muons or with pions. It is well known that a muon's mean life changes as a function of its velocity, however there is no data regarding what happens with decay processes with particles which reach velocities

$$v > c$$

However, in the following subsection, the results obtained for deBroglie waves of the particles in the deuteron nucleus, are in favour of muons' presence in the deuteron nucleus, rather than pions'. The reason for this conclusion is that, there is resonance between a nucleon's and a muon's deBroglie waves, what is not the case if pions are taken as participating objects in the deuteron nucleus.

We hope that this question, among others which arise from all the analysis presented, will be an inspiration for further investigation based on the newly presented ideas for nuclear forces and structures and that it will urge new types of experiment.

7. deBROGLIE WAVES IN THE DEUTERON NUCLEUS

According to deBroglie, each particle with mass *m* and velocity *v* of motion, is associated by the waves with wavelength,

$$l = \frac{h}{p} \tag{468}$$

where,

$$p = mv \tag{469}$$

then,

$$l = \frac{h}{mv} \tag{470}$$

We shall present the results of computations of deBroglie wavelengths for the nucleons and muons in the first version of the structure of the deuteron nucleus, and for the nucleons and pions in the second version.

We have seen that in the muon version of the deuteron nucleus, the masses of the nucleons are,

$$m'_p = m'_n = m' = 1.485 \cdot 10^{-27}\ kg$$

and their tangential velocities are,

$$v'_p = v'_n = v = 4.533 \cdot 10^{8}\ m/s$$

Thus, the wavelengths of the nucleons deBroglie waves are,

$$l'_p = l'_n = l' = 9.835 \cdot 10^{-16}\ m \tag{471}$$

The mass of the muons is,

$$m_m = 0.188 \cdot 10^{-27}\ kg$$

and their tangential velocities are,

$$v_m = 3.16 \cdot 10^{8}\ m/s$$

Hence, the wavelength of the muon's deBroglie waves is,

$$l_m = 88.9 \cdot 10^{-16}\ m \tag{472}$$

The ratio of these two wavelengths is,

$$\frac{l_m}{l'} = 9.04 \tag{473}$$

Since this ratio could be considered as an integer, it indicates the resonance between the nucleon's and muon's deBroglie waves in the deuteron nucleus.

In the version with pions in the deuteron nucleus, the masses of the nucleons are,

$$m'_p = m'_n = m' = 1.38 \cdot 10^{-27}\ kg$$

and their tangential velocities are,

$$v'_p = v'_n = v' = 4.533 \cdot 10^{8}\ m/s$$

Thus, the wavelengths of the nucleon’s deBroglie waves are,

$$l\,'_p = l\,'_n = l\,' = 1.058\cdot 10^{-15}\ m$$

The mass of the pions is,

$$m_p = 0.248\cdot 10^{-28}\ kg$$

and their tangential velocities are,

$$v_p = 3.96\cdot 10^{8}\ m/s$$

The wavelength of pion’s deBroglie waves is,

$$l_p = 6.74\cdot 10^{-15}\ m \tag{474}$$

The ratio of these two wavelengths is,

$$\frac{l_p}{l\,'} = 6.37 \tag{475}$$

It is not an integer, and therefore there is no resonant effect between these two deBroglie waves.

Let us consider what would be the result of computation if π^o were taken into account, with the supposition that π^o might be participating particles in the deuteron nucleus.

The masses of the nucleons in such a case would be,

$$m_p\,' = m_n\,' = m' = 1.4632\cdot 10^{-27}\ kg \tag{476}$$

and their tangential velocities are again,

$$v' = 4.533\cdot 10^{8}\ m/s \tag{477}$$

hence deBroglie waves of these nucleons would have the wavelength,

$$l_p\,' = l_n\,' = l\,' = 9.98\cdot 10^{-16}\ m \tag{478}$$

The mass of the π^o is,

$$m_{p^o} = 0.24\cdot 10^{-27}\ kg \tag{479}$$

and their tangential velocities are,

$$v_{p^o} = 3.96 \cdot 10^8 \ m/s \tag{480}$$

thus the wavelength of their deBroglie waves is,

$$l_{p^o} = 69.59 \cdot 10^{-16} \ m \tag{481}$$

and the ratio between these two wavelengths yields,

$$\frac{l_{p^o}}{l'} = 6.973 \tag{482}$$

This ratio could be considered as very close to an integer, what indicates the possibility of resonance between the deBroglie waves of π^o and those of nucleons. However, the presence of π^o in the deuteron nucleus is ruled out because of other reasons, which will be explained when the magnetic moment of the deuteron nucleus is explained and computed.

Before we offer any conclusion about the structure of the deuteron nucleus, namely, which other particles beside nucleons are presented in it, we need one citation from Reference [15]: Since pions have unit isospin the excitation of new isospin states not accessible to nucleon, α-particle, or deuteron nucleus excitation becomes possible. For example, in the change exchange reaction,

$$A + p^+ \rightarrow p^- + B \tag{483}$$

it is possible to explore states that differ in isospin from those of the ground state by as much as two units.

Now, we may conclude: the deuteron nucleus structure consists of two nucleons, μ^- and μ^+ muons. However, there still remains a question: are the muons directly emitted and absorbed by the nucleons or there are some intermediate processes which make it possible for the muons to be the active objects participating in the formation of the nucleus structure and in the formation of nuclear forces which keep all particles in one system. We shall try to answer to that question in the next subsection.

8. CHARGE CONJUGATION AND PARITY CONSERVATION OF NUCLEONS, LEPTONS AND MESONS IN THE DEUTERON NUCLEUS

The results of the latter subsection strongly support the supposition for the muon version of the SLR and QMT deuteron nucleus model.

It will be necessary to consider what the other consequences of this conclusion are.

It seems logical to assume two possibilities of how the muons can be included into the deuteron nucleus:

a) μ^{-} and μ^{+} muons are directly emitted and absorbed by nucleons,
b) at first, pions are emitted from the nucleons, and after that, as a result of decaying processes, μ^{-} and μ^{+} muons are produced.

In the previous subsections, on several occasions, it has been mentioned that when the proton and the neutron reach a certain distance apart them, in the $l_{ce} - l_{cp}$ region, there is charge exchange between these nucleons. However, this charge exchange is only partly dependent on the mutual distance, it is rather a result of the whole process of deuteron nucleus formation. A very important part of deuteron nucleus formation is the emission and absorption of leptons and mesons. Hence, the proton neutron charge exchange, is a process taking place at the certain distance between them, however, it is associated by the emission and absorption of leptons and mesons. These processes cannot be considered separately, firstly, because the charge conjugation and parity (CP) conservation cannot be conserved, and secondly, and no less important, the proton and neutron would lose their charge attributes and nucleon-lepton-meson processes become elusive.

In the first version with direct emission of μ^{-} and μ^{+} the charge conjugate parity is conserved and does not need additional discussion.

We will elaborate more thoroughly on the possibility for the production of muons by pions emitted initially from the nucleons.

Consider the case when both nucleons emit π^{-} pions, which may decay either by the electron process, or by the muon process.

If the proton emits π^{-} which decays by the process

$$p^{-} \rightarrow m^{-} + \overline{n_{m}} \tag{484}$$

then μ^{-} has already been produced.

When the neutron absorbs μ -neutrino, the decay process yields,

$$n + n_m \to p' + m^- \tag{485}$$

Now, we have two μ^- muons, but actually we need one μ^- and one μ^+ muon.

Let us assume that the neutron has also emitted π^-, which will have electron decay, then,

$$p^- \to e^- + \overline{n}_e \tag{486}$$

The electron is absorbed by the original proton, and decay is by the process,

$$p + e^- \to n' + n_{\mathrm{e}} \tag{487}$$

The residual nucleons from the decaying process we shall designate by accent acute, that is for proton *n*’ and for neutron *n*’.

Electron neutrino n_e will be absorbed by proton *p*’ and will decay by the process,

$$p' + n_e \to n' + m^+ \tag{488}$$

From this, we have obtained μ^+, and now we do have in the deuteron nucleus two nucleons and two muons, that is, μ^- and μ^+. However, the charge conjugation and parity conservation is not preserved because it appears that there is one μ^- surplus.

There are two possibilities as to what may happen with this μ^-.

As we have stated already, one μ^- is supposed to stay as a part of the nucleus structure, while μ^+ has to be created by other processes. The other μ^- may decay by two kinds of process. One is,

$$m^- \to e^- + n_m + \overline{n_e} \tag{489}$$

which satisfies the lepton conservation, according to the so called Puppi triangle [15], however there an alternative possibility for the decay process should be considered, that is,

$$m^- \to e^- + \overline{n_m} + n_e \tag{490}$$

The existence or non existence of this reaction still remains to be investigated [15]. This reaction is more convenient for our processes here, because it lends n_e for the reaction in Equation (488), for the production of μ^+.

The positive muon decay is by the process [17],

$$m^{+} \rightarrow e^{+} + n_{e} + \overline{n_{m}} \qquad (491)$$

From this we may consider that μ^{-} and μ^{+} are produced in the nucleon-lepton-meson reactions, in the process of formation of the deuteron nucleus. Thus, we may conclude that the deuteron nucleus structure consists of,

$$\begin{array}{ccc} & m^{-} & \\ / & & \backslash \\ \textit{proton} & & \textit{neutron} \\ \backslash & & / \\ & m^{+} & \end{array} \qquad (492)$$

Fig. 13, shows schematically the newly proposed deuteron nucleus model defined by the SLR theory.

It has to be pointed out that in Equations (485), (488) we need n_m and n_e respectively, while in Equations (484), (486) respectively, $\overline{n_m}$ and $\overline{n_e}$ are obtained, which certainly is not the same. Beside that we must admit that mean lives of all participating particles have been neglected, simply because we do not know this magnitude for the particles when they are in motion with superluminary velocities.

As a result of all this, the above statements cannot be considered as settled questions. We do not have all the information about particle characteristics when they are in motion with superluminary velocities. Therefore, the content of this subsection should be taken as a contemplation about possibilities to apply the processes to the frame of reference with $v < c$ to the frame of reference with $v > c$.

9. THE MAGNETIC MOMENT OF THE DEUTERON NUCLEUS

The spin and the magnetic moment of the nucleons are introduced in order to explain super fine structure of the spectral lines by the analogy of the spin and intrinsic magnetic moment of the electron to explain the fine structure of the electronic system of the atom [17].

In 1928 Pauli proposed a hypothesis for the existence of spin I and magnetic moment m_I. The interaction of the nucleon's magnetic moment with magnetic fields of electrons leads to additional splitting of spectral lines. In order to explain the extremely small value of this splitting Pauli proposed the magnetic moment of the proton to be equal to the nuclear Bohr magneton, that is [17],

$$m_P = \frac{e\hbar}{2m_P\, c} = \frac{m_e}{m_P} m_B \tag{493}$$

where,

$$m_B = 9.273 \cdot 10^{-24} \;\; J\, T^{-1} \tag{494}$$

is the Bohr magneton.

Before we go further with the analysis, it is useful to discuss Equation (493). Let us remind ourselves how we have defined and determined the constant M_c which connects the superluminary frame of reference g ’ with the frame of reference g where $v < c$.

It has been stated by Equations (202) and (212) that,

$$M_c = 0.811 \frac{l_{ce}}{l_{cp}} = 0.811 \frac{m_e}{m_p} = 4.42 \cdot 10^{-3}$$

When two reactions have been included in the computations, the value 8.11 has been changed to 0.8447, and constant M_c becomes,

$$M_c = 4.6 \cdot 10^{-3}$$

We would like to emphasise the analogy between the Pauli’s idea to express the magnetic moment by the quotient m_e / m_p and the same quotient as a constant which determines mass properties of the vacuum in the region l_{ce} - l_{cp} , where the superluminary frame of reference transformation is supposed to be valid.

Now, we may return to the deuteron nucleus magnetic moment.

The two known nucleons - the neutron and the proton differ from each other very significantly in the way they are charged. The proton is electrically charged and the neutron is electrically neutral. However, both nucleons have an internal spin,

$$s = 1/2$$

and therefore they are classified as fermions, that is, particles which obey Fermi-Dirac statistics. Their intrinsic magnetic moments are [15],

for proton: m_p = 2.793 nuclear magnetons (nm); (495)
for neutron: m_n = - 1.913 nuclear magnetons (nm). (496)

In current theories the deuteron nucleus magnetic moment is computed as follows [15], [17],

$$m_{(d)t} = m_p + m_n = 0.88\ nm \tag{497}$$

while experimentally observed value is,

$$m_{(d)\exp} = 0.8734\ nm \tag{498}$$

The difference between the latter two values,

$$\Delta m_d = 6.6 \cdot 10^{-3}\ nm \tag{499}$$

is not theoretically explained by current theories, neither is it understood as a result of systematic error in the computations nor in the experimental measurements.

The new deuteron nucleus model we have proposed here, offers an explanation of where this difference comes from.

As a contrast to the current theories for the deuteron nucleus, according to the proposed new model, based on the principles of SLR and QMT, all participating objects consisting in the deuteron nucleus structure: the proton, neutron and two muons (m^- and m^+) are rotating. Nucleons are rotating in one direction, while two muons are rotating in the opposite direction. Therefore, the **deuteron nucleus should have its own, intrinsic magnetic moment**, which is also in contrast to the current theories for magnetic properties of the deuteron nucleus.

Because the two muons, μ^- and μ^+ , are rotating in the same direction and have two opposite charges their net magnetic moment is zero. However, the charge of two rotating nucleons produces the magnetic moment of the deuteron nucleus, which should be considered as an intrinsic magnitude of this nucleus.

We have already elaborated on the question of charge conjugation and parity conservation in the previous section, but here we need to know that both nucleons are rotating in the same direction and that their total charge is,

$$q = e = 1.6 \cdot 10^{-19}\ C \tag{500}$$

Thus, according to the new proposed deuteron nucleus model, the intrinsic magnetic moment of this nucleus is,

$$m_{di} = \frac{erv}{2} M_c \tag{501}$$

where,

$$v = 4.533 \cdot 10^8\ m/s$$

is the tangential velocity of the nucleons,

$$r = 2 \cdot 10^{-16}\ m$$

is the radius of the circle of rotation of the nucleons, and,

$$M_c = 4.6 \cdot 10^{-3}$$

Hence, Equation (501) yields the value,

$$m_{di} = 6.606 \cdot 10^{-3}\ nm \tag{502}$$

Comparison of this value with the value of Equation (499) shows that these two values are practically identical because the difference is only 0.09%.

This result proves the difference between the observed and the computed values of the deuteron nucleus magnetic moment in current theories which is actually the intrinsic magnetic moment, defined by the SLR theory.

Now, we may compute the total magnetic moment of the deuteron nucleus by introducing its intrinsic magnetic moment. Thus,

$$m_d = m_p + m_n - m_{di} = 0.87339\ nm \tag{503}$$

By this computation we have obtained the theoretical value of the deuteron nucleus' magnetic moment in accordance of 0.001% with the observed one. The intrinsic magnetic moment m_{di} is produced by motion of the positive charge, and still it has the opposite sign of the intrinsic magnetic moment of the proton. This question deserves an additional analysis.

Such a good accordance between computed and observed values of the deuteron nucleus' magnetic moment could be considered as a strong justification of the principles of SLR and QMT on which the new proposed deuteron nucleus model is based.

These results could be inspirational for new experiments. First of all, it is necessary to verify the theoretically obtained results. However, these results may urge new ideas for stimulated nuclear reactions where the deuteron nucleus will be engaged. Why the term ”stimulated”?

The reported experimental results for polarization of the proton beam [22], urge the necessity to use a similar method to polarize the deuteron nucleus beam, if the intrinsic magnetic moment of this nucleus is to be experimentally verified. The positive results of these new proposed experiments, would not have only fundamental consequences but practical too. If the proton beam can be polarized and if also, the deuteron nucleus beam can be polarized, then it seems that the term ”stimulated” nuclear reaction will emerge as a necessity to explain certain processes.

IV. PROTON-NEUTRON SCATTERING EXPLAINED BY SUPERLUMINARY RELATIVITY AND QUANTUM MASS THEORY

We shall offer an explanation for proton-neutron scattering, based on the Superluminary Relativity and the Quantum Mass Theory principles. Before we do that, we shall show in brief how the current theories explain *p - n* scattering. For that purpose we shall give a short citation from Ref. [15]. In this reference it is stated: ”Nucleon-nucleon scattering at high energies (200 MeV laboratory energy and more) shows that *at very small separations the nucleon-nucleon interaction becomes very strongly repulsive*. This is often referred to as a *hard core* in the nucleon-nucleon potential, whose radius, it turns out, has to be taken as,

$$r_c \approx 0.5\ fm \tag{504}$$

to fit the scattering data. It should be emphasised, however, that all we really know is that the interaction becomes repulsive at such short distances, but whether it really takes the form of an infinite repulsive hard core, or whether it takes other possible forms *we do not really know at this stage*. This repulsive part in the nucleon-nucleon interaction is partly responsible for the *saturation of nuclear forces*”. And further in this context it is stated [15]: ”*Our understanding of nuclear forces is still rather limited*.”

In the Superluminary Relativity theory presented here we have offered a new approach for the explanation of nuclear forces, according to which nuclear forces have a complex nature and consist of the following forces:

1. Attractive forces produced by the gravitational field between the masses of the all participating objects in the nuclei, such as: nucleons, mesons and muons. **The gravitational field here corresponds to the Newtonian definition of gravitation, with that significance that the gravitational constant here differs from the one, which is valid for big masses and big distances**. The gravitational constant here

depends on the vacuum property characteristic for distances and masses, which correspond to the nuclear structures, and is determined by the Quantum Mass Theory principles.

2. Coulomb repulsive forces between the effective charges of the participating particles in the nucleus. The effective charges of the particles are a result of charge exchange processes at the considered distances.

3. Repulsive forces, that is, centrifugal forces, which appear as a result of the rotation of the particles, there, where such motion of the particles in the nuclei is taking place.

Because of all these, the forces are precisely defined by the Superluminary Relativity and the Quantum Mass Theory principles. They can be numerically determined for each particle-particle interaction, and consequently the net results can be determined in the nuclear structures, that is, in nuclei. Consequently, these forces can be determined for proton-neutron interaction in the scattering phenomena.

Hence, we are now in a position to offer a precise explanation for the forces, which are responsible for proton-neutron scattering, instead of vague terms such as ”hard core” or ”saturation of nuclear forces”.

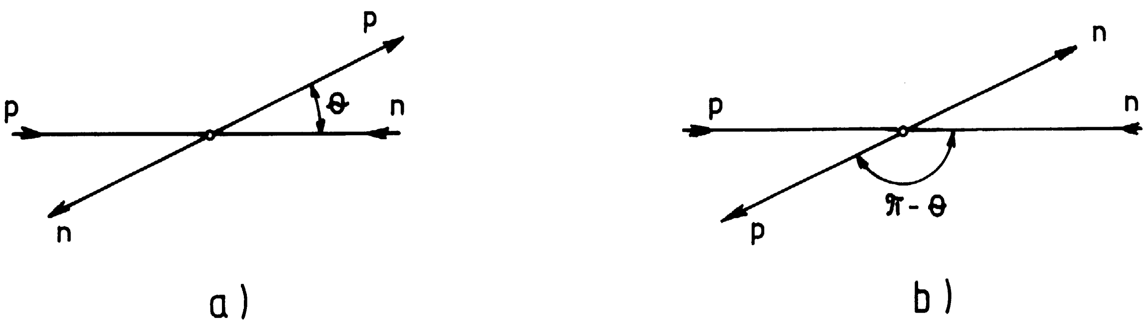


Fig. 14 Schematic description of proton - neutron scattering according to current theories.
a) Scattering of the original proton though the angle θ when charge exchange between nucleons does not take place.
b) Scattering of the original proton looks like a backward scattering by an angle π - θ, when charge exchange between nucleons is taking place.

Fig. 14, shows proton-neutron scattering as it is understood by current theories. Fig. 14a presents proton-neutron scattering which is called ”no charge exchange between the nucleons”, while Fig. 14b shows *p - n* scattering, called ”charge exchange between the nucleons”.

Current theories do not explain how this charge exchange is taking place, and why in the first case it is not happening. It is not explained, whether it is an instantaneous effect, or the proton charge is transferred to the neutron gradually, starting from the certain distance between them and when this process ends up with complete transfer of this charge.

In the case which is called ”no charge exchange” (Fig. 14a), the incident proton sustains its electric properties during its interaction with the neutron, and after the scattering phenomena it continues to be a proton. The same can be said for the neutron. In the case which is called ”charge exchange” (Fig. 14b), the incident proton completely transfers its charge to the neutron and turns into a neutron and the opposite process happens with the neutron, that is, it receives the whole proton charge and after scattering becomes a proton.

In our explanation of *p - n* scattering, the nucleons do not change their electric nature, namely, the incident proton continues to be a proton and after scattering in both cases, and the same happens with the neutron.

We shall consider the case when proton and neutron do not have any initial kinetic energy because for such a case we have precisely determined data. However, the conclusions from this case are applicable to other cases when nucleons have considerable energy.

In the case we shall consider, the nucleons are attracted only by the gravitational force between their masses.

It is important to point out that in current theories the distance [15], is given as

$$r \approx 0.5 \ fm$$

where repulsive forces begin to act upon the approaching nucleons, while the radii of both nucleons, that is the proton and neutron, are of the order of,

$$r \approx 0.8 \ fm \tag{505}$$

This means that nucleons have to come so close to each other that they practically have to penetrate through each others’ surface thickness, which is empirically determined to be of the order of [15], [17],

$$t \approx 2.4 \ fm \tag{506}$$

If this is taken into account then the nucleons may reach the distance given by Equation (504), but even with this important supposition, the explanation of current theories for the repulsive forces between nucleons in the described phenomena, remains vague.

We shall need a similar assumption about the distance between the nucleons, however as a contrast to the above explanation here we will offer precisely defined forces with the possibility of being numerically determined.

In Table 4, there are attractive F_m and repulsive F_e forces which act between the proton and neutron when they reach certain distances from each other. First, we shall give the values of these forces, discuss it, and then explain how they have been computed.

Thus, when the proton and neutron are at the mutual distance,

$$r_5 = 0.636\ fm \tag{507}$$

the attractive force prevails over the repulsive force, that is,

$$\left|F_{attractive}\right| > \left|F_{repulsive}\right| \tag{508}$$

because,

$$F_m = 517.7\ N \tag{509}$$

while,

$$F_e = 130\ N \tag{510}$$

At the distance,

$$r_6 = 0.14\ fm \tag{511}$$

the repulsive force prevails over the attractive force, that is,

$$\left|F_{repulsive}\right| > \left|F_{attractive}\right| \tag{512}$$

because,

$$F_m = 2321\ N \tag{513}$$

while,

$$F_e = 2880\ N \tag{514}$$

Now, we have to answer to several important questions. First of all we have to clear up the question about the distance where the repulsive force starts to prevail.

Here, we need one important assumption which we hope will not only justify this analysis for the case when nucleons do not have initial kinetic energy, but which may encourage this approach to be applied to the cases when the nucleons have considerable laboratory energy.

We have computed the Coulomb force for the next vacuum permittivity constant,

$$e_0 = 8.8544 \cdot 10^{-12}\ N^{-1}\ m^{-2}\ C^2$$

By the presented theory we have shown that in the distances l_{ce} - l_{cp} vacuum properties are different from those in other parts of the space, where electromagnetic properties are prevailing, which had a direct consequence on the gravitational constant G'_n . It seems justified to assume that **in the range of the space where electromagnetic properties are not prevailing, the vacuum permittivity is different from the permittivity in the vacuum where these properties are prevailing**. Therefore, we shall assume that,

$$e'_0 < e_0 \tag{515}$$

where e_o' is vacuum permittivity in the range l_{ce} - l_{cp} .

In such a case the repulsive force, that is the Coulomb force, will prevail significantly over the gravitational force, and it will take place on the distances, which are close to the distance,

$$r \geq 0.5\ fm \tag{516}$$

Unfortunately we are not in the position to determine the value of e_o' at this stage, and it remains as a challenging task. Despite that, we believe that the explanation of *p-n* scattering based on the Superluminary Relativity and the Quantum Mass Theory principles is more acceptable because it uses magnitudes which are precisely defined and numerically determined as a contrast to the vague terms ”hard core” and ”saturation nuclear forces”.

Now, we may return to the main question: How have we computed the attractive and repulsive forces in the *p-n* interaction?

We have computed the Coulomb force between nucleons, despite the fact that one is charged - the proton, and the other one is neutral - the neutron.

According to the first assumption of Superluminary Relativity and Quantum Mass Theory, when the proton and neutron enter the region l_{ce} - l_{cp} , and when the distance between them is,

$$r < l_{ce} \tag{517}$$

charge exchange starts, so that, when they reach a certain distance, both nucleons will have the same charge, i.e.,

$$q_p = q_n = \frac{e}{2} = 0.8 \cdot 10^{-19}\ C \tag{518}$$

The values of F_e in Table 4 are obtained with this value of charge for both nucleons, as if they had it from the very beginning when they enter the region l_{ce} - l_{cp} .

Fig. 15a, shows the case of *p-n* scattering called ”no charge exchange” in current theories, but the analysis by SLR and QMT principles shows that charge exchange is taking place here too, but temporarily and at a certain distance only.

There are two circles. One circle has a diameter l_{ce} , and the inner circle with a diameter l_{cp} . The proton will enter the region l_{ce} - l_{cp} when it passes the point A_p . It is supposed that the neutron will cross the circle l_{ce} at the same time, when it passes the point A_n . When it happens, besides the attraction of the gravitational force,

$$F_m = G'_n \frac{m'_p\, m'_n}{r^2} \tag{519}$$

the Coulomb repulsive force will start to act between the charges of both nucleons, i.e.,

$$F_e = \frac{1}{4 p\, e_o} \frac{\left(\frac{e}{2}\right)\left(\frac{e}{2}\right)}{r^2} = \frac{1}{16\, p\, e_o} \frac{e^2}{r^2} \tag{520}$$

When the proton reaches the point C_p , and neutron the point C_n then,

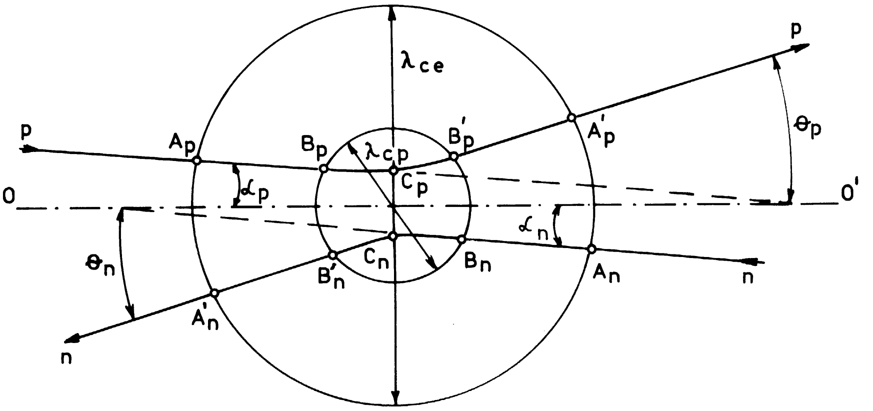
$$|F_e| > |F_m| \tag{521}$$

that is,

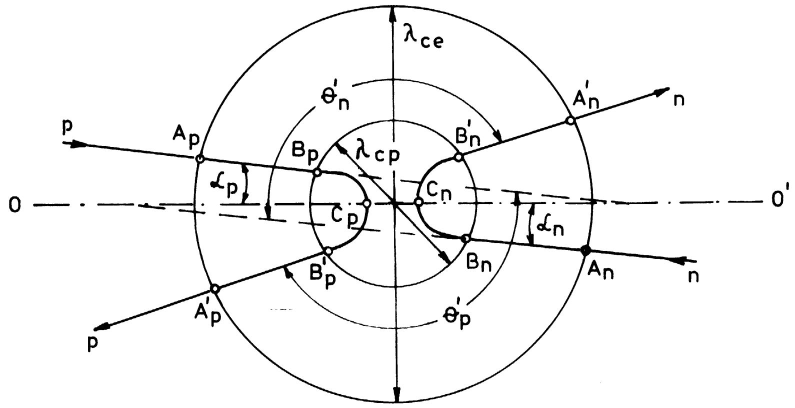
$$|F_{repulsive}| > |F_{attractive}| \tag{522}$$

and the proton and the neutron will begin to depart from each other. After this, the opposite charge exchange will take place, that is, the proton will regain its charge, and the neutron will regain its neutrality. When both nucleons leave the region l_{ce} - l_{cp} at the points A'_p and A'_n , they will have their original attributes, that is, the proton will be $+e$ charged and the neutron will be a neutral particle.

Thus, even in this case in current theories called ”no charge exchange” scattering, charge exchange is taking place but only temporarily when they are at



a)



b)

Fig. 15 Schematic description of proton - neutron scattering according to Superluminary Relativity principles. According to SLR principles in any proton - neutron scattering, charge exchange is taking place, but only temporarily when they are at a certain mutual distance. α_p and α_n are proton and neutron angles of incidence, respectively, towards the axis of symmetry O - O'. λ_{ce} and λ_{cp} are electron and proton Compton wavelengths, respectively. The distance C_p - C_n is the proton - neutron distance when $F_{repulsive} > F_{attractive}$ is established.

a) On dependence of the angles of incidence α_p and α_n , the proton is scattered through the angle θ_p and neutron through the angle θ_n .

b) On dependence of the angles of incidence α_p and α_n , the proton is scattered through the angle θ'_p and neutron is scattered through the angle θ'_n . Which case occurs in proton - neutron scattering a) or b) depends only on the angles of incidence.

a certain range of mutual distance, and where the Coulomb force between them appears.

The angles of incidence of proton and neutron towards the axis of symmetry O - O' are a_p and a_n , respectively.

The deflection angles of the proton and neutron are θ_p and θ_n, respectively.

Fig. 15b, shows presented the case of p - n interaction called the "charge exchange" scattering in current theories. Charge exchange is taking place here, too, according to the SLR and QMT principles. The process of interaction and the appearance of Coulomb force, with the consequence of reaching the position, where,

$$\left|F_{repulsive}\right| > \left|F_{attractive}\right| \tag{523}$$

is absolutely the same as it was described in the previous case. The only difference here is that deviation angles θ_p and θ_n of the proton and neutron, respectively are much bigger. This case in current theories is referred to as charged exchange because the final result of p - n scattering gives the macroscopic impression that nucleons have exchanged their electrical properties forever, that is, the proton turns into a neutron and vice versa. According to the interpretation based on SLR and QMT principles, the same as in the first case, the exchange of the charge between the nucleons happens only temporarily, when they find themselves at the certain mutual distance, and after that they regain their original electrical properties.

What case will be obtained in p - n interaction with scattering phenomena, depends only on the angles of incidence towards the axis of symmetry O - O'.

The precise analysis, which will include the angles of incidence and angles of deflection, is a challenging task and inspiration for new p - n scattering experiments.

V. SPECIAL AND GENERAL RELATIVITY CONNECTED BY SUPERLUMINARY RELATIVITY AND QUANTUM MASS THEORY

The principles of Superluminary Relativity are based on the original concept for the superluminary frame of reference and on the modified concepts of Special Relativity, General Relativity and Quantum Mass Theory, that is:

1. The concept of the superluminary frame of reference gives the transformation that connects the magnitudes from the frame of reference where $v < c$ is possible only, with frame of reference where $v > c$ is possible.

2. The concept for energy-mass equivalency is taken from Special Relativity, and applied to the frame of reference with $v > c$.

3. From the General Relativity is taken:
   - the laws of physics must be of such a nature that they apply to reference systems in any kind of motion relative to the mass distribution of the universe,
   - the concept that $c \neq constant$.

4. In the Quantum Mass Theory it the concept for gravitation between the masses in the distances characteristic for atomic systems is defined. This principle is modified in the Superluminary Relativity for distances between particles characteristic for nuclear systems as are nuclei. The concept for equilibrium between the attractive forces and repulsive forces in atomic systems, modified to the nuclear system, that is nuclei, is also taken from QMT.

Because of all this, Superluminary Relativity and Quantum Mass Theory connect Special Relativity with General Relativity principles applied to the nuclear structures.

In the following subsections we will elaborate on this statement.

1. THE VELOCITY OF LIGHT IN A VACUUM

In Subsections I/2 and II/4.1 we have already used the equation for light in a vacuum from the General Relativity, where the velocity of light is expressed as a function of gravitation, that is,

$$c \approx c\left(1 - \frac{2Gm}{c^2\, r}\right) \tag{524}$$

By the analysis of the Superluminary Relativity, among the other results, the magnitude,

$$M'_c = M_c \; c^2 \tag{525}$$

has appeared, which has been used to compute the velocity of the light *c'* in the superluminary frame of reference *g* '. Thus,

$$c' = 2.0347 \cdot 10^7 \; m/s \tag{526}$$

We would like to find out whether these two equations, that is, Equation (524), and Equation (525) are compatible. To do that, first of all we have to modify Equation (524) for the superluminary frame of reference.

To use Equation (524) in the superluminary frame of reference we have to make the following two modifications:

a) The gravitational constant as it has been defined by QMT applied to SLR, that is G'_n will be used as a gravitational constant.

b) In Equation (524) the constant M_c has to be introduced.

After introducing, these two modifications, Equation (524) in the SLR becomes,

$$c' \approx c\left(1 - \frac{2G'_n\, m}{c^2\, r\, M_c}\right) \tag{527}$$

for the gravitational constant,

$$G'_n = G'_d = 4.6 \cdot 10^{26} \; N m^2 \; kg^{-2} \tag{528}$$

for distance,

$$r_d = 4 \cdot 10^{-15}\ m \tag{529}$$

mass of the proton,

$$m = m_p = 1.67252 \cdot 10^{-27}\ kg \tag{530}$$

and,

$$M_c = 4.6 \cdot 10^{-3} \tag{531}$$

Equation (527) yields,

$$c' = 2.1667 \cdot 10^{7}\ m/s \tag{532}$$

The accordance of the values for *c'*, obtained by Equation (525) and Equation (527) is,

$$\Delta c' = 6.5\% \tag{533}$$

which could be considered as highly accurate, specially because Equations (524) and (527) are approximate ones.

The fact that Einstein's Equation (524) for the velocity of light in a vacuum as a function of the gravitation, given in the General Relativity, can be modified to Equation (527) shows that these two theories are compatible. So that the obtained value for *c'* according to the General Relativity is in good accordance with the value obtained by the magnitude M'_c derived in the Superluminary Relativity.

2. COMPATIBILITY OF THE PRESENTED THEORY FOR SUPERLUMINARY RELATIVITY WITH VALID THEORIES FOR NUCLEAR STRUCTURES

In the two nucleon system, as for instance the *p* - *n* system is, there is a force which will cause nucleons to be within the range of their nuclear interaction. According to nuclear physics [15], there will be an increase in their relative momentum because of the uncertainty relation [7], [15],

$$\Delta p \Delta r \geq \hbar \tag{534}$$

We have already analysed this phenomenon by applying the principles of SLR and principles of QMT in the Section III. The results of that analysis show that the nuclear force that causes the nucleons to be in the range of their nuclear interaction is in fact Newton's gravitational force. We have defined and computed not only that force, but also all relevant magnitudes of the gravitational field among the considered nucleons.

The results of the analysis have shown that as a result of the nuclear force, that is Newton's gravitational force between nucleons, the increase in their kinetic energy is taking place.

In nuclear physics this increase in the kinetic energy in the centre-of-mass system is given by the expression [15],

$$E_{kin} = \frac{(\Delta p)^2}{2(m/2)} \approx \frac{\hbar^2}{m r^2} \tag{535}$$

where the reduced mass $m/2$ is used to emphasise that we are dealing with the relative kinetic energy.

We shall apply the latter expression for both energy states of the p - n system, that is, for intermediate the energy state and for the stable energy state. For the intermediate energy state of the p - n system, when the distance between nucleons is,

$$r_1 = 2.6 \cdot 10^{-13}\ m \tag{536}$$

we have computed the kinetic energy of the system by Einstein's equation,

$$E_{kin} = 2\, m' c^2 \left(\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 1 \right) \tag{537}$$

which yields,

$$E_{kin} = 2.04\ MeV \tag{538}$$

We need to point out here that when the p - n system is in its intermediate energy state, then it is in the system g , where $v < c$ is possible and where the principles of Special Relativity are valid. Therefore, we have used Equation (537) to compute the kinetic energy of the system.

We shall use now Equation (535) to compute the kinetic energy for the same state of the system, but instead of reduced mass $m/2$ we shall take the real mass of nucleons, that is, m. Hence, Equation (535) becomes,

$$E_{kin} \approx \frac{\hbar^2}{2 m r^2} \tag{539}$$

which yields,

$$E_{kin} = 3.064 \ MeV \tag{540}$$

It has to be pointed out that both equations, that is, Equation (535) and Equation (537) are from current theories for nucleons, and despite that the achieved accuracy is only 50%. However, it should not be forgotten that Equation (535) gives only the approximate value. Therefore, the results should be considered sufficiently good because values of the same order at least have been obtained.

Now, we shall use Equation (539) for the stable energy state of the system, to compute the kinetic energy of the system. However, the *p* - *n* system is now in the range of the space where principles of SLR and principles of QMT are valid, that is, where $v > c$ is possible, therefore Equation (539) needs to be modified for the system *g '*, and it becomes,

$$E_{kin} \approx \frac{\hbar^2}{2mr^2} M_c^{\ 2} \tag{541}$$

which yields,

$$E_{kin} = 2.73 \ MeV \tag{542}$$

For this state of the *p* - *n* system we have used Equation (145) from SLR theory to compute the kinetic energy,

$$E_{kin} = 2m'c^2 \ M_c \left(1 - \sqrt{1 - \frac{c^2}{v^2}}\right) \tag{543}$$

which yields,

$$E_{kin} = 2.236 \ MeV \tag{544}$$

The comparison of the values from Equation (541) and Equation (543) show a difference of 22%. It is worthwhile pointing out here that now better accuracy is obtained than in the previous case when two equations were used for kinetic energy from current theories, when the difference was 50%.

Therefore, we may conclude that accordance between modified Equation (541) from nuclear physics and Equation (543) from the presented theory shows that principles of the SLR theory and principles of the QMT are compatible with current theories of nuclear physics.

3. SPACE-TIME CURVATURE

The Special Theory of Relativity in its essence is a generalisation of some physical laws by including relativistic Newtonian laws. However, this theory is restricted only for motions without acceleration [1], [2]. Despite the fact that this theory explains many phenomena, Einstein considered to be a theory with some restrictions, and therefore named it *special*. The main reason is, that it is valid only for systems, which are considered as inertial. Hence, in the systems with accelerations, the Lorentz transformation can not be applied.

In Section II of this book, the analysis which shows the possibility of the concepts of Special Relativity being extended into the system where $v > c$, is presented. However, the main postulate of Special Relativity is not valid any more, i.e., the velocity of light is not constant, and it depends on the masses and the distances between them. Because of this, the presented theory for system g ' with $v > c$, seems to be closer to General Relativity rather than to Special Relativity. The task of this section is to show that the theory for SLR and QMT connects the Special Theory and General Theory of Relativity. Here, we shall elaborate on only some aspects of the connection between the theories mentioned.

From the Special Theory of Relativity in the presented theory for SLR, the following factor from the Lorentz transformation is taken,

$$g = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} \tag{545}$$

and modified into the form,

$$g' = \sqrt{1-\frac{c^2}{v^2}} \tag{546}$$

In the Section II, the frame of reference with $v > c$, has been explained as a region of the vacuum where its properties connected with masses of the particles prevail over its electromagnetic properties. Thus, besides the restrictions of the Special Theory to the inertial systems, it is comprehended here, that the Special Theory has one more restriction: it is valid only in the part of space where electromagnetic properties of the vacuum are prevailing, expressed by the postulate $c = constant$. In Section II, we have shown that for the part of space where the vacuum properties which are connected with masses of the bodies, are prevailing over the electromagnetic properties, it is c ¹ *constant* . Now, we have to show that in the frame of reference g ', the acceleration of the particles is possible, and by that the system g ', becomes a non-inertial system. By these two main assumptions: firstly, that c ¹ *constant*, and secondly, that system g ' is not an inertial system, the presented theory becomes closer to General Relativity. However, we should not forget that we have taken very important concepts from Special Relativity, for instance the equivalency between the mass of a particle and its energy.

To show that in the system *g* ', the acceleration of the particles is possible, we had to determine the nuclear forces which have been mentioned in Subsection II/4, as a cause for the rotation of the particles. In Section III, we have defined these forces and computed their numerical values. Now, we have to say something again about the main principles of General Relativity, and their consequences in physics.

In order to extend the concepts of Special Relativity into all coordinate systems, i.e., including the system where acceleration of the bodies is possible, Einstein first of all alters the main postulate of Special Relativity. Instead of,

$$v = \mathit{constant} \tag{547}$$

it is assumed,

$$v \neq \mathit{constant} \tag{548}$$

The essential standpoint on which Einstein formulates the principles of General Relativity is the conception that inertial and gravitational masses are equal, and consequently there is equivalency of the accelerated motion with gravitational field, called *principle of equivalency* by Einstein [3], [6]. The analysis of the presented theory for system *g* ', is developed for particles which rotate, therefore it would be worthwhile presenting in short Einstein's explanation of, why in General Relativity Euclidean geometry cannot be applied. It is well known that the geometry of Special Relativity is actually Euclidean geometry.

Here we shall describe one of the Einstein's imagined experiments, which explains that General Relativity needs geometry different to Euclidean geometry [3], [6], [16].

Let us consider two coordinate systems: S and S' with the same Z axis and same coordinate zero points. In the planes OXY and O'X'Y', there are two circles. System S' starts to rotate around Z' axis with constant angular velocity. To determine physical laws in this system, Einstein assumes that along the periphery of the circle in the system S' there are a large number of short rigid sticks present, much shorter than the radius of the circle. The same kind of sticks is taken along the diameter of the circle. When system S' is at rest, then the quotient of the sum of all the lengths of the sticks on the periphery and the sum of all the lengths of the sticks along the diameter, is equal to p , that is,

$$\frac{C_i}{D} = p \tag{549}$$

where,

C_i - is the circumference of the circle, and
D - is the diameter of the circle.

When system S’ starts to rotate, according to Einstein, all sticks along the periphery will be contracted, because of the Lorentz contraction principle. The sticks along the diameter will not be contracted because their lengths are normal to the direction of movement during the rotation. Einstein states that in the case of rotation of system S’, it will be,

$$\frac{C_i}{D} < p \tag{550}$$

Equation (549) corresponds to the principles of Euclidean geometry, but Equation (550) does not correspond to this geometry.

Similar difficulties emerge when the Lorentz principle for the dilatation of time is considered.

To formulate the new postulates for General Relativity, Einstein needed to abandon Euclidean geometry, which was an important and also daring decision. In short, it can be described as follows: in the space with bodies, i.e., with gravitational field and acceleration, Euclidean geometry is not valid. For the principles of General Relativity, Einstein needed non-Euclidean geometry, and offers physical interpretations of non-Euclidean geometry [3], [6], [16].

In the following subsection, we shall see how this imagined experiment of Einstein’s can be applied to our SLR system.

The fundaments of non-Euclidean geometry were paved on by Riemann, Gauss, Lobachevski and Bolyai. However, Einstein for his geometry uses the analogy with Gauss geometry of curvilinear coordinates and the Decart spherical and cylindrical system [6].

According to the General Relativity, gravitational law besides gravitation and space-time properties, includes the corresponding classical laws and principles of the Special Relativity, with necessary modifications [6]. We would like to emphasise here the term ”modification”, because we have also obtained the main factor g' of the presented theory, by modification. In our case, it was modification of the factor g from the Special Relativity into factor g'.

In the title of this subsection there is the term ”curvature”. *Curvature* is not a simple geometrical term in General Relativity, it is an important mathematical magnitude. It does not have simple space-like meaning, neither it is the real curvature in three dimensional geometry. In geometry, *curvature* is presented by magnitude defined by Riemann (1854) and by Christoffel (1865). This magnitude is determined by the Riemann-Christoffel tensor [6]. In General Relativity the *Einstein curvature tensor* [3], [6], plays a very important role.

According to the Special Relativity, the presence of bodies in the space, does not influence the properties of the space and does not have influence on time, either. In contrast to this, according to the General Relativity, the presence of the bodies has influence on the space-time continuum. Therefore, in the General Relativity, the velocity of light is not constant, i.e.,

c ¹ *constant*

The light propagating in the space with a gravitational field created by the body with mass *m*, according to General Relativity will have the velocity [3], [6],

$$c' \approx c\left(1 - \frac{2Gm}{rc^2}\right) \tag{551}$$

By using the last equation it is possible to compute the deflection of the light beam in the gravitational field.

The deflection of the light beam in the gravitational field can be computed by the next two equations:

$$a = \frac{c - c'}{c} \tag{552}$$

or,

$$a = \frac{4Gm}{rc^2} \tag{553}$$

By the analysis in Subsection II/4.1 we had obtained the equation for the velocity of light in a vacuum for the superluminary frame of reference *g* ’,

$$c' = \sqrt{M_c\, c^2} \tag{554}$$

This is the velocity of light in a vacuum in the range l_{ce} - l_{cp} of the space.

In Subsection 1 of this section, the correlation of Equations (551) and (554) is shown, and by that the compatibility of SLR with the General Theory of Relativity, and also the necessity for using non-Euclidean geometry in the superluminary frame of reference *g* ’.

4. SPACE-TIME CURVATURE IN THE SUPERLUMINARY FRAME OF REFERENCE *g* ’

In order to apply Einstein’s imaginary experiment with rotating rigid sticks in the superluminary frame of reference *g* ’, it is necessary to use the relative length *L* obtained by the superluminary transformation in Subsection II/3.1.

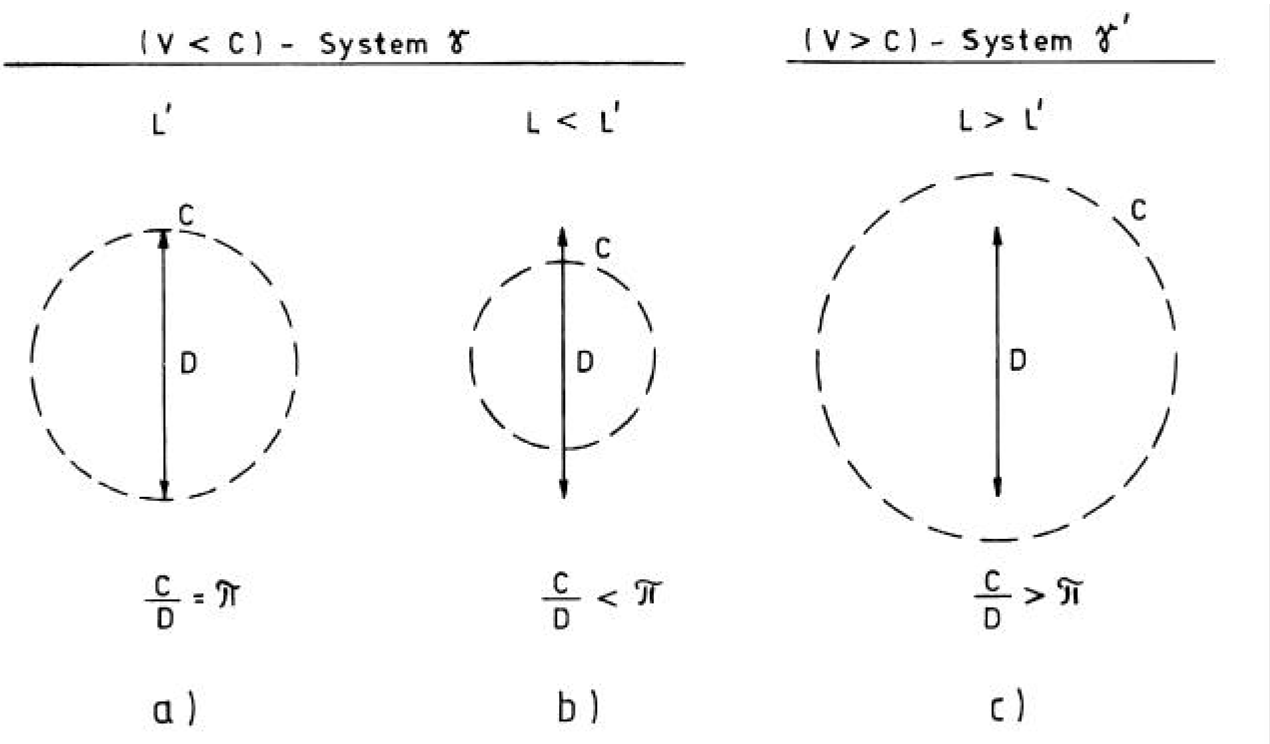


Fig. 16 Schematic description of Einstein's imagined experiment with rotating rigid sticks.
a) Rigid sticks which form the circle with circumference C and diameter D are at rest in the frame of reference S'.
b) Rigid sticks rotating with $v < c$ observed from the frame of reference S.
c) Rigid sticks rotating with $v > c$ observed from the system S.

Despite the fact that it is not possible to present non-Euclidean geometry by Euclidean principles, we shall try to present schematically the main concept of Einstein imagined experiment with rotating rigid sticks in both systems, that is, in the system *g* , where only $v < c$ is possible, and in the system *g* ’, where $v > c$ is possible. Fig. 16 is such a schematic presentation of these imagined experiments.

In Fig. 16a and Fig. 16b, *g* designates the system where $v < c$ and where the Lorentz transformation and Special Relativity principles are valid, while, in

Fig. 16c, g ’ designates the system where $v > c$ is possible and superluminary transformation and SLR principles are valid.

Fig. 16a presents the case when the circle with rigid sticks is not rotating and where Euclidean geometry is valid, thus,

$$\frac{C}{D} = p$$

where,

C - is the circumference of the circle consisting of rigid sticks, and
D - is the diameter consisting also of rigid sticks.

Fig. 16b presents the experiment when the circle of the rigid sticks is rotating and because the sticks get shorter, it is,

$$\frac{C}{D} < p$$

hence, the non-Euclidean geometry is valid.

Fig. 16c presents the same imagined experiment with rotating rigid sticks, but now in the system g ’. Because in this system the sticks of the circle are getting longer compared to the system g , the next expression is obtained,

$$\frac{C}{D} > p$$

From the last expression a very interesting task emerges: to find out whether the Einstein curvature tensor is applicable to the superluminary frame of reference. This task remains to be solved.

VI. BIG BANG AND THE SINGULARITY OF THE SUPERLUMINARY FRAME OF REFERENCE *g'*

According to Hawking: Einstein predicted with his General Theory of Relativity, that space-time began at the big bang singularity and would come to an end either at the big crunch singularity (if the whole universe recollapsed), or at singularity inside a black hole (if a local region such as a star, were to collapse) [23].

The big bang theory for the creation of the universe is based on three crucial magnitudes.

At the immediate moment before the big bang occurs, the time is,

$$T = 0 \tag{555}$$

The whole matter of the universe is inside the volume,

$$V \approx 0 \tag{556}$$

and the mass of the whole matter in the universe is,

$$m \approx \infty \tag{557}$$

Three seconds after the big bang occurs, the universe already has considerable dimensions, and the mass is spread out into the expanding space, the process lasting for ever after since then.

The presented theory for the superluminary frame of reference is based on the assumption that its principles are valid only in the range l_{ce} - l_{cp}. However, it seems justified that vacuum properties cannot be restricted only to the certain sections of the space but they are rather general properties. What we have assumed in the presented theory is that in some regions of the space some of the vacuum properties may prevail over some other properties, which also seems to be justifiable.

If we accept that vacuum properties are universal, then we may assume that SLR principles are universal too. With this new concept for SLR, that is for the g'

- system, it would be worthwhile considering what might be the consequences of understanding the nature of the universe, if the principles of SLR were applied to the universe.

In Section II, we have shown, that for,

$$v = c \tag{558}$$

it is,

$$g\,' = 0$$

which could be considered as a singularity of the system *g* ’.

If we apply this *g* ’- system singularity to the universe we shall come up with some very interesting ideas.

Thus, for

$$g\,' = 0 \tag{559}$$

according to Equation (102) the time is,

$$T = 0 \tag{560}$$

and the dimension of the universe according to Equation (100) is,

$$V = \infty \tag{561}$$

and according to Equation (142) the whole mass of the matter in the universe is,

$$m = 0 \tag{562}$$

Despite $m = 0$ for $g\,' = 0$, when also $T = 0$, the space of the universe is not void, the matter has not been annihilated. According to Section II, the whole matter would be transferred into massless particles, charged massless particles, physical fields and intrinsic vacuum energy. In the very short period of time after $T = 0$, the basic three particles with a mass proton, neutron and electron are created out of the massless particles, physical fields and the vacuum energy spread into the space in the vacuum.

The crucial data for the big bang and *g* ’- system singularity are presented in Table 5. If we compare the values of the corresponding magnitudes we shall come up to the conclusion that the *g* ’- system singularity could be comprehended as an ultimate stage of the expanding universe. The time $T = 0$ in the *g* ’- system could represent the moment immediately before which the opposite process to the expansion of the universe begins. At that moment the universe reaches its ultimate dimensions,

$$V = \infty$$

and mass spread into that volume, gives,

$$m = 0$$

After the moment,

$$T = 0$$

the new process of the universe, process of the recollapsing, the process of shrinking of the universe, which is in accordance with Einstein's predictions for the fate of the universe begins. This new proposed *g* '- system singularity of the universe could be in favour with the theories for pulsating processes in the universe, as well.

T a b l e 5

Magnitudes	Big Bang	Superluminary Frame of Reference
Time	0	0
Volume	0	∞
Mass	∞	0

THE FINAL CONCLUSIONS

The new Theory of Superluminary Relativity presented and proposed here is based on the superluminary frame of reference transformation and on the modified principles of Special Relativity, General Relativity and Quantum Mass Theory.

The analysis is performed for a nucleus with two nucleons, that is, for the deuteron nucleus. On the bases of the principles of Superluminary Relativity a new deuteron nucleus model is offered.

Here are the main conclusions drawn from the results of the analysis.

1. **The superluminary frame of reference transformation is defined, so that it connects the magnitudes of the frame reference where** $v > c$ **is possible with frame of reference, where only** $v < c$ **is possible**.

2. It is proven that the first principle of General Relativity is valid for the superluminary frame of reference, because **the energy conservation law is preserved in the analysed particle reactions and nuclear structures, in contrast to current theories where violation of the conservation laws is either accepted, or justified by some assumptions**.

3. **The concept for equivalency of the mass and energy of the Special Relativity is adopted in the SLR theory presented**.

4. Nuclear forces are explained as a net result of:

   - gravitational forces between the masses of all participating objects in the nucleus, where **Newton's gravitational equation is used with a gravitational constant defined by the Quantum Mass Theory, for masses and distances characteristic for nuclear structures**;

   - gravitational constant defined by the Quantum Mass Theory for the range of the space determined by the electron's and proton's Compton's wavelengths, is a magnitude dependent on the distance between the particles; by this, the gravitational constant is turning into a linearly changeable magnitude which indicates the possibility of the vacuum for this part of the space to have its own structure;

- Coulomb's forces between participating objects in the nucleus, when charge conjugation and parity conservation is applied to the proton and neutron, according to the Superluminary Relativity principles;

- muons and mesons are participating objects in the nuclear structures, thus, they participate in the nuclear forces by their masses and charges.

5. A new deuteron nucleus model is proposed. According to this model, the deuteron nucleus consists of a proton and a neutron that rotate in the same direction with velocity $v > c$. Besides these two nucleons, the deuteron nucleus consists of two binding particles. Three possibilities are considered:

   - each nucleon emits and absorbs one muon,
   - each nucleon emits and absorbs one pion, and
   - each nucleon emits a pion, but after their decay the effective participation in the nuclear forces comes from muons.

   The results of the analysis are in the favour of muon participation in the nuclear forces because there is resonance between the nucleon's and muon's deBroglie waves.

6. The new deuteron nucleus model has the same binding energy and the same mutual distance between the nucleons with the experimentally observed values, which could be considered as one of the experimental proofs for the validity of the principles of the proposed Superluminary Relativity and for the newly proposed deuteron nucleus model.

7. **The main experimental verification of the presented Theory of Superluminary Relativity has excellent accordance between computed and observed values of the magnetic moment of the deuteron nucleus**.
   According to current theories, the deuteron nucleus does not have an intrinsic magnetic moment and theoretically is expressed as a sum of the proton and neutron magnetic moments. So the value obtained for its magnetic moment differs from the experimentally observed value. This difference cannot be theoretically explained and it cannot be taken as a consequence of the theoretical and experimental systematic errors. The proposed Theory of Superluminary Relativity offers a very good explanation for this.

According to the newly proposed deuteron nucleus model, the deuteron nucleus has an intrinsic magnetic moment as a result of the nucleon's rotation. It is important to emphasise that the value of the intrinsic magnetic moment of the deuteron nucleus is almost identical with the difference that appears in the current theories between computed and observed values. Thus, when the intrinsic magnetic moment is introduced into the computation of the deuteron nucleus' magnetic moment the accordance between the computed and observed values is 0.001%.

8. If it is accepted that the deuteron nucleus has an intrinsic magnetic moment, then new ideas for experiments where this new phenomenon will be employed should be expected to emerge. For instance, the method which has already been publicly reported, for the polarization of proton beams, could be modified for the polarization of deuteron nucleus beams. It seems rather obvious what the consequences of the combination of these two new possibilities for experiments with fusion processes could be.

9. A new approach is offered for the explanation of proton-neutron scattering. Instead of the vague terms ”hard core” and ”saturation of nuclear forces” used in current theories to explain the repulsion effects in proton-neutron scattering. **The Superluminary Relativity principles offer well defined and numerically determined forces which cause the nucleons to scatter, and at which distances these forces are effective**.

10. **There is compatibility between the proposed Theory of Superluminary Relativity and current theories of nuclear physics**. For instance, the equation for the kinetic energy of the particles derived by the SLR analysis, is compatible with the kinetic energy equation for the particles in nuclear physics.

11. **Special and General Relativity are connected by Superluminary Relativity and Quantum Mass Theory**.
For instance, the equation from General Relativity for the velocity of light in a vacuum as a function of gravitation, modified for the superluminary frame of reference, is compatible with the equation for the velocity of light in a vacuum, derived by the SLR analysis.

12. **Hopefully, the newly proposed SLR theory might be inspirational not only for new types of experiment with nuclear reactions but for practical applications as well.**

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IX. APPENDIX

Why is the term **superluminary** used instead of the term **superluminal**?

According to the Cambridge Encyclopedia, ed. D. Crystal, Cambridge University Press, 1994:

Lumen - SI unit of luminous flux, defined as the luminous flux emitted from a light source of intensity of one candle into a solid angle of one steradion.

According to the Oxford English Dictionary, Volume X, Oxford, At the Clarendon Press, 1970:

Luminal - of or belonging to a lumen;
Luminary - pertaining to light.

The velocity of light is not connected with luminous flux, but it is a magnitude pertaining to light, hence, it seems more appropriate that the phenomena with faster-than-light speeds should be expressed by the term **superluminary**.